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The Nassau Electric Ry. Co., of Brooklyn, has made a proposal to the trustees of the New York and Brooklyn bridge, covering the operation of trolley cars over the tracks of the present bridge railway The company offers to make all changes necessary, at its own expense, and to run cars at 10 seconds headway over the bridge and carry 40,000 passengers per hour. A trial of one year is asked, for, with the privilege of a 50-year franchise if the scheme proves satisfactory; and the company is ready to execute a bond of $250,000 to insure faithful performance of its contract. Chief Engineer C. C. Martin, of the bridge, opposed the use of the trolley as impracticable and unsafe He says that as it takes as long to load one trolley car with 50 or 60 people as it would to load a bridge train of 4 cars with 400 passengers; congestion would surely follow. Then the responsibility now centered on one man would be divided among other motormen, and accidents would occur. Mr. Martin says that when the improvements now under construction are completed, the bridge trains will be able to run on 45 seconds headway and to carry 32,000 passengers per hour.

A loaded train, going down grade, generating electrical power which will be used in pulling the empty train back, is a project which is being considered by the Marquette Iron Range R. R. Co., according to a report in the Detroit "Tribune" of Dec. 14. The proposed line is to run from Ishpeming, Mich., the center of ore supply of the Marquette district of the Lake Superior region, to Marquette, the nearest lake port, 15 miles distant. There is a fall of about 800 ft. between the mines and the lake. On account of the rugged topography of the country, an ordinary endless wire cable line appears to be impracticable. The electrical plan, projected by Mr. Hiram A. Burt, president of the Marquette & Iron Range R. R. Co., is described as follows:

> An electrical trolley line will be equipped with the ordinary gondola ore cars, holding about 25 tons each, but will be minus the power plant.] The heavily loaded trains descending the grade, which will be made nearly uniform, will have no brakes, except for emergencies, but each short train of 10 or 15 cars will have a motor car, which will be fitted with a dynamo. The energy created by the loaded trains descending will be transformed into electricity by the dynamo, except such part of it as is required to carry the train forward at a fair rate of speed. This power will be transferred to the trolley line and taken off by the empty train which will make the ascent at the same time. The difference in weight between the light and loaded trains will suffice to overcome the loss of power through friction and leakage.

A complete block signal system and interlocking system will be installed by the New York Central R. R. on the new four-track steel viaduct on Park Ave., from 90th st. to 135th st., New York City, which forms part of the approach to the Grand Central Station, replacing the former masonry viaduct and open cut. At the north end of the viaduct is the four-**track drawbridge crossing the Harlem River. The** Patenall lock-and-block system will be used, and **all signals will be operated by pipe connections. The home signals will have two blades, operated and controlled by two levers through a single line of connections, thus giving a three-position signal by day and night. There will also be a National torpedo machine at each home signal.** The contract for this entire work has been awarded to the National Switch & Signal Co., of Easton, Pa. The traffic over the line is very heavy.

The most serious railway accident of the week was a derailment on the Denver & Rio Grande R. R., near Leadville, Colo., Jan. 1. A special newspaper train from Denver was racing with a similar train on the Colorado Midland R. R., when it jumped the track at Malta; and dashed into the station building. The engineman and fireman were killed.—A head collision of passenger trains occurred on the Baltimore & Ohio Southwestern R. R. at Cole City, O., Dec. 30, in which one man was killed and eight were injured.

A trestle on the South Carolina & Georgia R. R., near Charleston, S. C., settled suddenly under a freight train, Dec. 24, causing the train to jump the track and wreck the structure. Three men were killed.—A trestle at McAfee, Ky., on the Louisville Southern Ry., gave way under a freight train, Dec. 21, owing to one of the cars being derailed. One man was hurt.

A combination motor and passenger car on the Metropolitan Elevated Electric R. R., at Chicago, Ill., ran against the bumpers at the end of the line at West Harrison and 4th Sts., Dec. 23, knocking the bumpers down. The car went over into the street, and the second car went partially over, the front resting on the street and the rear on the structure. The motorman, conductor and one passenger were injured, but not seriously. The motorman claimed that he could not shut off the current. The inefficiency of the ordinary bumpers on elevated railways was commented on in an issue of Jan. 17, 1895. A similar accident occurred a few days later on the same road.

The locomotive of a local freight train on the Pennsylvania R. R. exploded at Princeton Junction, N. J., on Dec. 23, killing the engineer. The train had been halted by a signal at the time and the engineer had just left the engine and was crossing the track to the station when the explosion took place. It was one of the oldest engines on the road.

A slip occurred in a blast furnace of the Shoenberger Steel Co., at Pittsburg, Pa., on the morning of Dec. 23. The furnace had been repaired and started up a few hours before. Seven men were engaged in finishing repairs on an adjoining furnace when the metal settled, allowing the burning gas to escape enveloping the tops of both furnaces and seriously burning seven men, two of whom may die.

A trestle at Milford, Ind., on the Cleveland, Cincinnati, Chicago & St. Louis Ry., gave way under a freight train Dec. 25. The engine and one car crossed in safety, but 13 cars went down. Nobody was hurt.

A head collision of electric cars occurred Dec. 19 near Clifton, N. J., on the line from Hoboken to Paterson and Passaic. The weather was foggy and cars were not running on a regular schedule, but one of the cars was considerably behind time and ran past one of the turnouts. Both cars were wrecked, and the stove in one of them was upset, the coals burning some of the passengers. One man was killed and another fatally injured, while 9 others were badly injured.

A train carrying 30 men on a mine track at the Mdivale Colliery, near Shamokin, Pa., on Dec. 18, broke away from the engine and ran back down a steep grade and was derailed at a curve. Four men were fatally injured.

A car on the Trans-Siberian Ry. caught fire Dec. 20, while the train was running, and as there was no means of communicating with the engineman, three persons were burned to death and a fourth was injured in jumping from the car.

A large gasoline tank exploded at Midland, Mich., on Dec. 17, under peculiar circumstances. It had developed several leaks and was removed from its place for repair. A plumber and three assistants had been at work on it for three days and were engaged in soldering up the holes when it suddenly blew up, and set fire to the room. All of the men were more or less injured.

The third floor of the Palace Clothing House, in Minneapolis, Minn., collapsed on Dec. 20, under a heavy load of wall paper. A space 25x50 ft. was cut through to the basement. Only one person was killed. The building was an old one.

The fly-wheel governor of an automatic cut-off engine in the power house of the Traction Company in Scranton, Pa., broke down on Dec. 16. The press reports say that the springs were stretched too far by the flying outward of the governor balls, when a heavy load on the engine was suddenly taken off. A dozen pieces of the governor flew in all directions, one of them going through the floor like a cannon ball. Such an accident is very unusual, but its possibility suggests an examination of the construction of fly-wheel governors, to learn what is likely to happen to them in the event of suddenly throwing off a heavy load.

A steam pipe exploded in the engine room of a large dry-goods store at No. 502 Fulton street, Brooklyn, N. Y., on Dec. 21, severely scalding three men. The Superintendent of Steam Boiler Inspection of the Police Department is reported to have said that the accident was probably due to the fact that the connection which exploded had been weakened by the settling of the boiler.

The erection of the ironwork for the Northwestern Elevated Ry. in Chicago is to be begun at once, and the work rapidly pushed so as to have the line in operation early in 1897. A map of this line and a full description and illustrations of the substructure and ironwork were given in Engineering News, Sept. 5, 1895. The contractors for the superstructure are the Union Bridge Co., of New York, N. Y., and the Elmira Bridge Co., of Elmira, N. Y. Mr. Charles V. Weston, Chicago, is Chief Engineer, and Mr. J. A. L. Waddell, M. Am. Soc. C. E., of Kansas City, Mo., is Consulting Engineer.

The Lake Erie Ship Canal plans and estimates have been submitted to the consulting engineers, Gen. H. L. Abbott, Maj. N. H. Hulton and Prof. L. M. Haupt. While no formal report has been made as yet, the Pittsburg "Dispatch" says the following conclusions have been practically arrived at: A 15 ft. canal with 340 ft. locks would accommodate the bulk of the vessels now engaged in lake traffic; the summit-level water supply, even during drouth, is sufficient for a canal with a freight capacity of 13,000,000 tons annually, and this capacity can be increased if the canal is deepened; the railway bridge crossing question is still in the hands of the engineers; the preliminary estimate of $27,000,000 to $30,000,000 is not far from the expectd cost. A canal of 8 or 10 ft. is impracticable, according to Gen. Abbot, because it would have to be deepened in a few years.

The Chicago drainage canal, according to the late address of Mr. Eckhart, the new president of the Board of Trustees, of the sanitary district of Chicago, has cost to date, $12,518,927.82, out of an aggregate of $19,080,846.31 called for by existing contracts. Under these contracts the work should be completed within the coming year. The contracts are soon to be let by the new board for the controlling works of the Des Plaines River; proposals have been received and bids have been opened for this work. Among the problems yet to be determined are the enlargement of the Des Plaines channel through Joliet and the maintenance of the Illinois and Michigan canal in connection with this enlargement. The deepening of the Chicago River, to insure the 300,000 cu. ft. of water needed at once, is another problem to be disposed of, and Mr. Eckhart hopes that the national government may assist in the dredging necessary, regarding the Chicago River as a public navigable stream.

THE SEWERAGE AND SUBSOIL DRAINAGE SYSTEM OF NEWTON, MASS.

By G. M. Warren, Assistant Engineer.

(With inset.)

The city of Newton, Mass., lies west of Boston, and about eight miles from the ocean. It is a beautiful and wealthy suburb, covering an area of about 20 square miles, with a present population of about 28,000, and a taxable valuation of $53,956,309. Naturally a community of this character would be one early to construct sewers, and it is probable that the city would have been so provided long ago had a feasible method of disposal been available.

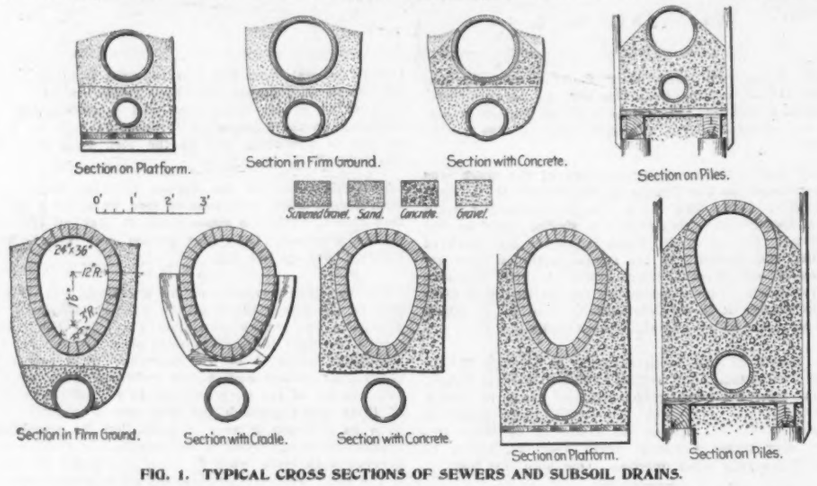

FIG. 1. TYPICAL CROSS SECTIONS OF SEWERS AND SUBSOIL DRAINS.

But the construction of the Charles River division of the Metropolitan Sewerage System (Eng. News, Jan. 25, 1894) solved the problem of disposal, and the city government of Newton on June 24, 1889, passed an order directing the making of surveys and plans for a drainage system. On Dec. 6, 1890, Mr. Albert F. Noyes, M. Am. Soc. C. E., then City Engineer, made a report. His design was adopted, and has been substantially followed in construction by himself until his resignation in July, 1893, when about 45 miles of sewers had been built, and since then by his successor in office, Mr. H. D. Woods, M. Am. Soc. C. E.

The Newton sewers, in accordance with the Metropolitan and the Boston Main Drainage Works,* the latter being especially designed with a view of ultimately taking the sewage of the lower Charles basin, are on the separate system. For the determination of sizes, the following assumptions were made: A population of 60 persons per acre in those parts of the city likely to be most thickly settled, and adjacent to the railway lines; 40 persons per acre in all other parts of the city; 7 cu. ft. of sewage per person per day; maximum flow twice the mean flow, and sewer half full when taking the maximum flow.

With these assumptions, sizes for the drainage of any specified area were determined from a diagram plotted from Kutter's formula. In the mains the full theoretical size has seldom been employed, as such sizes would be unnecessarily large and expensive.

The grades for the most part are sufficiently great to render the sewers self-cleansing; for the different sizes the minimum grades shown in Table I. were decided upon, and have rarely been made less.

TABLE I.—Grades for Different Sizes of Sewers at Newton, Mass., and Velocities with Sewers One-Half Full.

Size of sewer, ins.	Minimum fall per 100.	Velocity, ft. per sec.
8 pipe	0.50	2.35
10 "	0.40	2.46
12 "	0.32	2.52
15 "	0.30	2.81
18 "	0.24	2.93
21 "	0.20	2.84
24 "	0.16	2.86
24 x 36 brick	0.10	....

* See Engineering News, Jan. 5 and 26 and May 10, 1894, for Boston Main Drainage, and Jan. 25, Feb. 8, May 3, 10 and 17 for Metropolitan.—Ed.

On account of the cost to the city of Newton for the maintenance of the Metropolitan sewer in proportion to the amount of sewage discharged into it, and of the liability of reaching the limit of the capacity of the sewers at an earlier date than anticipated, every effort has been made to prevent any excess of water entering the sewers beyond what is necessary for flushing. To accomplish this, as well as to reduce the level of the ground water, a subsoil drain has been built immediately beneath the sewers. These subdrains are laid with open joints, have branches for connecting cellars, and discharge into the several brooks and waterways of the city. The proper size of the subdrain has largely been a matter of judgment, but as the system has grown a careful study of its workings would seem to show that the underdrain should be of sufficient size, when not over two-thirds full, to discharge 1,000,000 gallons per 24 hours per square mile of area drained.

Fig. 1 shows the general cross-section of sewer and subdrain in varying formations. In Newton and Newtonville the subdrain was laid 4 ins. to one side, and about 8 ins. below the sewer invert; the inspection hole to the subdrain was brought up to the water table, thus leaving the sewer unobstructed through the manhole. But the objections to this form of construction—namely, additional cost on account of extra width of trench necessary, and the possibility of disturbing the alinement of the sewer, because of unequal settlement, have led to the placing of the subdrain vertically beneath the invert in all subsequent work.

The invert of the manhole has been divided and carried on either side of a chimney or inspection chamber to the subdrain; this chamber in the brick sewers is a cast iron framework, shown in detail by Fig. 2, and in connection with a manhole in Fig. 4; in the pipe sewers the chamber is of brick, carried as high or higher than the springing line of the sewer, and covered with an iron slab.

At the present time the principal objection to this form of construction is the obstruction to the free and direct flow of sewage through the manhole; but this objection is met by turning the sewage to one side of the inspection chamber till such time as the sewers shall have reached an adequate flow. In general, this form of obstruction has given satisfaction.

Up to the present time about 60 miles of sewer have been built of which some 48 miles are 8-inch pipe. Every precaution has been taken in construction to secure efficiency and completeness.

Manholes, of which two general types are shown by Figs 3 and 4, are placed about 250 ft. apart, and between the same, except in rare instances, the sewers are straight both as to line and grade. The excavation, laying of pipe and refilling have been under the constant supervision of experienced inspectors in the employ of the city, so that poor workmanship and jobbery are almost unknown.

The best quality of vitrified salt-glazed, socket pipe has been used, and great pains taken to make every joint water-tight; a grouted jute gasket is first rammed tightly into the joint, which is then filled and surrounded with a generous amount of Portland cement mortar, which in turn is completely covered with American cement mortar. T-branches have been placed once in 25 ft. on either side of both sewer and subdrain and at such other points as seemed necessary.

No methods of automatic flushing have been employed. The flushing and inspection of sewers are performed by a flushing gang of two or three men provided with a hand-cart containing hose pipe, picks for removing manhole covers, and other necessary equipment. The usual method pursued has been as follows:

The sewer leading from a manhole is stopped by means of a large wooden plug, and a considerable quantity of water introduced by hose pipe attached to a neighboring hydrant. Upon the removal of the plug, to which a cord running to the surface is attached, the sewers are cleansed in a most thorough manner. Latterly many of the manholes have been connected directly with the city water mains by a 1½-in. pipe, a valve being placed just inside the manhole wall, thus doing away with the necessity and inconvenience of long lines of hose, and otherwise simplifying the operation.

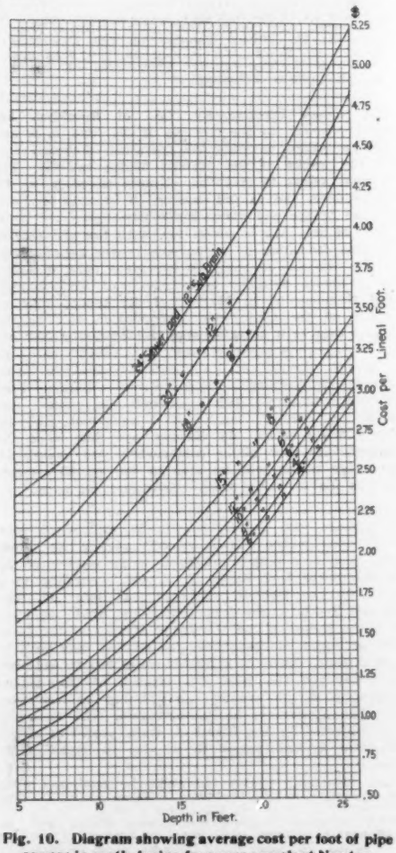

Fig. 10. Diagram showing average cost per foot of pipe sewers in earth during four years work at Newton.

Excavation of trenches.—6 to 15-in. sewer, 3 ft. wide; 18 to 24-in. sewer, 4 ft. wide.
0 to 8 ft. deep.....$0.50 per cu. yd.
8 to 14 ft. deep..... 0.75 per cu. yd.
14 to 20 ft. deep.....1.00 per cu. yd.
20 to 26 ft. deep..... 1.25 per cu. yd.
Socket pipe, 70% off list, plus 20% for branches.
Laying, 1 ct. per lin. ft. per in. of diam.
Sub-drain laying, including excavation, 25 cts. per lin. ft.

In one or two instances manholes have been specially constructed with a view to utilizing the water of a brook for flushing purposes; such a manhole is shown by Fig. 5. A cast iron cover, moving in a groove, is raised by means of an iron rod reaching to the surface; water enters the manhole, and after passing through a wire screen performs its work in the connecting sewer; the lower of the two inlet pipes shown is to provide for possible deepening of the brook.

The ventilation of sewers is effected by means of perforated manhole covers, shown by Fig. 6, and by the soil pipes, which are laid without the running trap, and are free and unobstructed from the sewer to the roof.

Up to the present time six connections have been made with the Metropolitan sewer. Table II. shows in a condensed form some information concerning these connections.

TABLE II.—Connections Between Newton and Metropolitan Sewerage Systems.

Location.	Size, ins.	Tributary area (—in acres.—) Present.	Ultimate.	Present pop.	Remarks.		
Nonantum St..	8	15	60	250	Reg.*	Sump.	Weir.
Hyde Brook...	21	282	532	4,300	"	"	"
Crescent St...	24x36	240	2,600	10,000	"	"	"
Cheese Cake Brook	24x36	330	4,670	9,300	"	"	"
Near Watertown line....	10	9	30	100	"		
Dalby St.....	12	10	36	300	"		

*Regulator.

The general style of these connections is shown by Fig. 7.* They consist essentially of a regulator manhole and a sump and weir manhole. The object of the regulator is to shut off the flow in the city sewer when the sewage in the Metropolitan sewer has reached a determined height, say, one-half to two-thirds full. In a cast iron tank, which is connected with the Metropolitan sewer by pipe (not shown), so that the water in each is at the same level, is a copper float. A lever arm, with center pivoted at one end of the tank, is attached to the copper float, while the other end of the arm carries a curved plate closely fitting the nozzle, or outlet, of the city sewer. The float rising with the sewage in the Metropolitan causes the plate to descend and shut off the city flow. This general mechanism was designed some 15 years ago by Mr. Joseph P. Davis, M. Am. Soc. C. E., then City Engineer of Boston.

The Newton sewerage system has few individual construction features. Two that may be mentioned are the drop manhole and subdrain overflow, at the corner of Washington and Elm Sts., West Newton, shown by Fig. 8, and the carrying of a 20-in. pipe sewer beneath the Sudbury River conduit of the Boston water-works. This conduit is about 9 × 7½ ft., with a concrete invert and a 12-in. brick arch, and at the time of crossing was in constant use. The bottom of the sewer excavation, a very wet, running sand, was about 24 ft. below the surface of the ground, and 12 ft. below the bottom of the concrete foundation of the conduit. In order to open the trench under the conduit, 24 piles, each 20 ft. long and 12 ins. in diameter, were first driven in pairs 3, 9 and 15 ft. each side of the sewer line and on both sides of the aqueduct. These piles were cut off about 2 ft. below the bottom of the conduit, and then, after tunneling out a space large enough to get the timbers in and allow room enough for a man to work, two 12 × 12-in. timbers, one on top of the other, were placed across each set of four piles, and the space between the top of the timbers and the conduit was tightly wedged. Before the excavation for the sewer was completed there was a section of the conduit about 35 ft. long, weighing with the contained water upwards of 125 tons, supported entirely by the piles.

After the sewer and subsoil drain, which were 20 and 12 ins., respectively, entirely bedded in Portland concrete, were completed, the whole excavation under the conduit, about 5 ft. wide at the bottom and some 18 ft. wide at the top, was filled with American cement concrete, to within about 3 ft. of the aqueduct. Then, after it was well set, four 12-in. brick walls were built on the concrete to support the conduit, and the timbers removed. The spaces between the walls and also where the outside sets of timbers had been, were filled in with dampened sand, carefully rammed, and the piles allowed to remain in. This work has been entirely successful, no settlement or leaks in the conduit resulting.

The finished maps and profiles of the sewers are upon Whatman cloth-mounted paper, in sheets 22 × 30 ins. The style of these maps is shown by Fig. 9, except that lines of different colors are employed, instead of the symbols shown in the drawing.

Each sheet has upon its lower portion on a scale of 40 ft. to the inch, a plan of the street with the abutting properties back to a depth of 180 or 200 ft. Upon this plan are shown all street lines, buildings, manholes, pipes, catchbasins, hydrants,

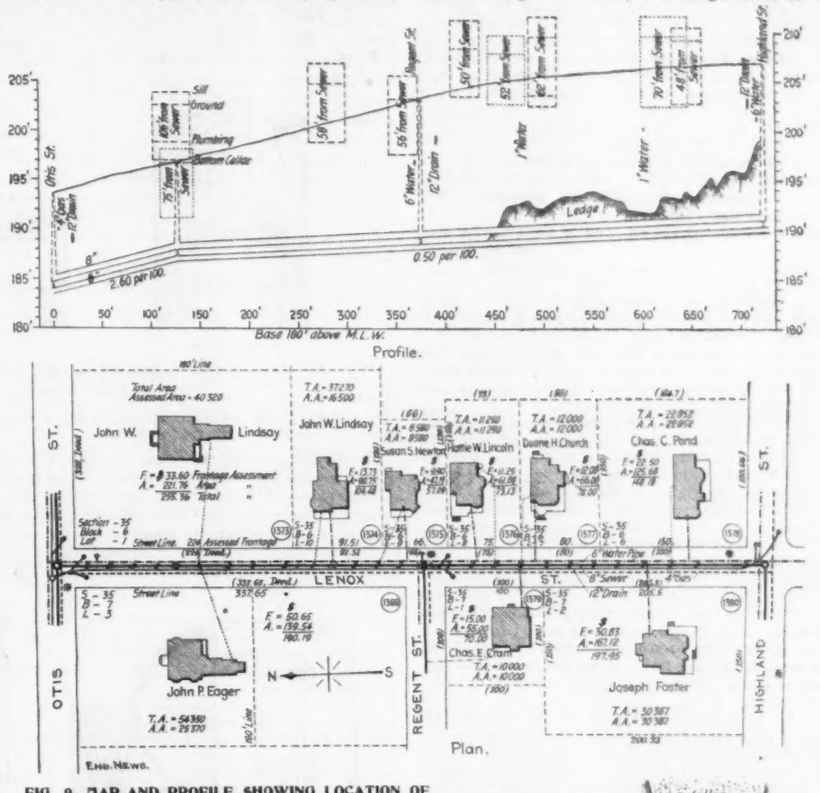

FIG. 9. MAP AND PROFILE SHOWING LOCATION OF SEWERS AND OTHER FACTS.

trees, lamp-posts, dimensions and areas of lots, assessed frontages and areas, and the amount of the assessment. On the upper portion of the sheet is a profile of the street along the sewer line on scales of 4 ft. and 40 ft. Here is plotted the sewer and subdrain with manholes and all intersecting pipes and conduits, the projection of each house showing elevation of sill, bottom of cellar, plumbing, and ground at house. The distance of houses back from the sewer is put on in figures; all information obtainable as to the character of the material and the limit of ledge, is here shown for ready reference.

These plans have been found to be almost indispensable in estimating cost of construction or house connections, in subsequent studies for street information, and finally as general reference plans.

The Newton sewers have cost to date $1,332,340. Newton Highlands and the Upper and Lower Falls are still unprovided with sewers, which will add several hundred thousand dollars more to the cost.

Assessment is made according to frontage and area, being 15 cts. per front foot and 5½ mills per sq. ft. back to a depth of 180 ft. from the street line, or to the drainage line if that be less. Up to the present time this rate of assessment has returned to the city only about 32% of the cost, owing to the expensive mains; but it is expected that ultimately the expense will be about equally borne by the city and by abutters. The following is a general statement of the sewer assessment in Newton:

Assessments levied and collected	$255,600
" uncollected	18,482
Due on apportioned accounts	102,873
" to be levied, estimated	60,000
	$436,955
Refunded and abated	16,443
	$420,512

The cost of house connections with the sewer and subdrain is borne by the owner desiring the connection. The method pursued is as follows: Upon notice being received by the City Engineer that a connection is desired, an engineer having in charge all house connection matters visits the ground and makes an estimate of the cost, which, under average conditions, will range from 55 to 70 cts. per running foot. Upon the abutter depositing with the city engineer or his agent the amount of this estimate the city makes the connection at the actual cost to itself. The difference is then refunded to the abutter. The house connections are mainly 5-in. best quality vitrified sewer pipe, and have a fall of not less than 1 in 50. With this size and grade, and the certainty of well-laid connections, obstructions and stoppages have been very rare. The subdrain connections where made are 4 ins. in diameter.

The carefully-prepared data, given in Table III., show the average units as derived from three years' sewer construction in Newton.

TABLE III.—Quantities of Material Used for Unit of Newtown Sewer.

Barrels of cement used per 100 lin. ft. of sewer.

Size of sewer.	Portland, 1½ to 1.	Rosendale, 3 to 1.
6-in. pipe	0.50	0.50
8-in. "	0.70	0.90
10-in. "	0.95	1.04
12-in. "	1.30	1.50
15-in. "	1.90	2.30
18-in. "	2.10	2.90
20-in. "	2.40	3.90
24-in. "	2.61	3.83

Rosendale, 1½ to 1.

24 × 36-in. brick	37.00 bbl. per 100 ft.
24 × 36-in. "	1.49 bbls. " cu. yd.
Manholes	1.50 " " " "

Number of brick used.

	Per cu. yd. of work.	Per bbl. of cement.
24 × 36-in.	520, with waste	340.5
24 × 36-in	560, no waste	.....
Manhole	500	333.3

The following are some of the more important clauses in the specifications:

*A somewhat similar connection, between the Brookline and Metropolitan systems, was shown in our issue of May 10, 1895.—Ed.

(15) Where rock is encountered it shall be uncovered, and, after it has been measured, shall be taken out to a depth of 6 ins. below grade of subdrain, or 6 ins. below the grade of sewer where there is no subdrain.

(17) All excavations to be measured or estimated either as earth or rock, the latter to include all boulders of 1 cu. yd. or more in volume; all other materials found in excavation, however hard, stiff, and compact, including soft and disintegrated rock which can be removed with a pick, shall be estimated and paid for as earth. All excavations for sewers in earth and rock trenches will be estimated 3 ft. in width for all sizes of pipe from 6 to 15 ins. in diameter, inclusive, for all depths; 4 ft. in width for all sizes of pipe from 18 to 24 ins. in diameter, inclusive, for all depths; 5 ft. in width for all brick sewers, for all depths; in depth earth will be estimated to sewer grade, and rock to a depth 6 ins. below sewer grade.

(26) The sand will be furnished by the contractor for use in the mixture of cement mortar. It must be clean, screened, sharp sand, free from loam, vegetable matter, or other foreign substances.

(27) The sand and cement used to make mortar shall be thoroughly mixed dry, and, unless otherwise directed by the engineer, in the following proportions:

One part, by measure, of cement and 1½ parts of sand, and a moderate dose of water is to be afterwards added to produce a paste of proper consistency, the whole to be thoroughly worked with hoes or other tools. The mortar shall be freshly mixed, only in sufficient quantity for the work in hand, in proper boxes made for the purpose. No mortar shall be used that has begun to set or has become hard.

(29) The gravel used for concrete shall consist of pebbles or broken stone of various sizes, no pebble to be more than 1½ ins., or less than ¼ in., in its greatest diameter. The gravel shall be free from clay or other objectionable material, and shall be mixed with sand and cement, in the proportion of not more than 5 parts, by measure, of gravel or broken stones to 2 parts of sand, and 1 part of cement.

(33) The hardest and most regular-shaped bricks are to be used in the invert of the sewer. The bricks shall be laid to line, with the ends in the line of the radii of the curves, and with as close joints (not exceeding ¼ in. for facework) as may be from time to time directed. Competent mechanics shall be employed for this work, and for the invert of the sewer and intersections, or groins, especially, the best skilled labor shall be employed.

(61) All pipes and specials shall be laid to grades as given by the engineer, and in such manner as he directs, with joints close and even butting all around, special care being taken that there is no sagging of the spigot end in the hub or sleeve and that a true, even surface is given to the invert throughout the entire length of the sewer.

A narrow gasket of jute (jute to be furnished by the city) shall be introduced between the hub and spigot, and properly caiked, so as to leave sufficient depth for the mortar, which shall then be used as specified. The space between the spigot and hub shall then be entirely filled with cement mortar on the bottom, sides, and top, and every precaution taken to secure a watertight joint. The mortar shall be applied with a rubber mitten, and a neat and proper bevel finish shall be given with the mortar to each joint. The interior of each joint must be scraped clean of all projecting mortar, and also, where the size of the pipe will permit, pointed. No length of pipe shall be laid until the previous length laid has had sufficient fine earth filled and tamped about it to firmly secure it in place, so as to prevent any movement or disturbance.

(73) The refilling around the subdrain shall be solidly made with selected clean gravel or broken stone of from ¼ in. to 1 in. in greatest diameter, to be furnished by the contractor.

(74) Over the refilling, the contractor shall furnish and place a continuous line of jute or other bagging, or inverted sod of such thickness as the engineer may direct.

(75) The excavation for this pipe shall be of sufficient width to allow a clear space of 6 ins. all around the sides of the pipe, the barrel of the pipe resting on solid ground, except in rock cut and in running sand, where a bed of 6 ins. of selected material will be placed below the pipe, or the joints may be made tight with cement mortar, as the engineer may direct.

(80) The brickwork in the walls of manholes shall be 8 ins. thick throughout, unless otherwise directed by the engineer, and shall be smoothly plastered on the outside with a ⅝-in. coating of mortar.

(86) The trench and other excavations shall be refilled with such excavated material and in such order as may be from time to time directed by the engineer. In covering the sewers and filling around manholes the earth shall be brought up evenly on both sides and all around the manholes, so that no unbalanced pressure can be brought to bear upon the masonry or pipe. The filling about all pipes and sewers, and for a depth of 2 ft. over them, shall be made of earth, free from stones, thoroughly and carefully tamped in layers not exceeding 4 ins., and special care shall be taken in filling about and over all pipe that the earth is thoroughly compacted to the full width of the trench, and no voids or pockets of soft, compressible material left under or about the sewer.

Backfilling shall be spread in layers not exceeding 1 ft. in thickness, unless otherwise specified, and shall be well watered and thoroughly rammed; or, where an abundance of water can be obtained, and the engineer so directs, it shall be thrown into the trench and allowed to settle into place through a suitable depth of water.

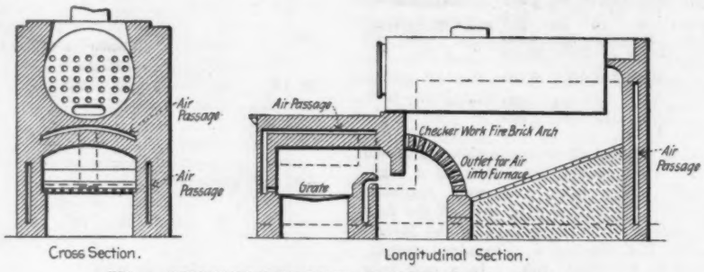

FIG. 1. REYNOLDS FIRE BRICK ARCH SMOKELESS FURNACE.
Frank Reynolds, Omaha, Neb., Inventor.

No backfilling shall be made with stone larger than 6 ins. in diameter, or with frozen earth.

The diagram shown by Fig. 10 gives the cost of pipe sewers with subdrain in earth based on the average prices obtained during four years' work in Newton. The writer has been connected with the office of the City Engineer almost from the beginning of the sewer work. His especial duties upon the sewerage system have been the details of design and construction and the work connected with the assessment of abutting property owners.

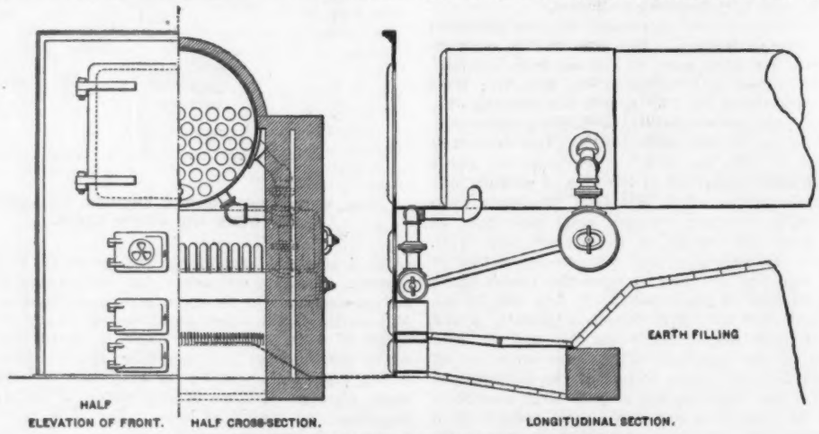

FIG. 2. HAWLEY DOWN DRAFT SMOKELESS FURNACE.
The Hawley Down Draft Furnace Co., Chicago, Ill.

SMOKE PREVENTION AND SMOKELESS FURNACES.

Smoke prevention seems to be a problem which all manufacturing cities are called upon to solve at one time or another. A dozen years ago or more, Manchester, Birmingham, Glasgow and other British cities were struggling with the Smoke Abatement Act; to-day a number of American cities are in the throes of a similar struggle. The problem is one of vital interest, and in another column we have discussed its general features at some length. In the following paragraphs is given a more specific discussion of smokeless furnaces and kindred devices. In many respects this discussion is elementary, and has purposely been made so, for the people who most need to be reached have not a technical training, and the more intricate problems of combustion of interest to the engineer, if discussed here, would defeat the ends of the article. At the same time the devices described will be found of interest to engineers, as care has been taken to select for description those which represent current practice in a number of prominent cities.

Conditions of Combustion.—When fresh coal is thrown onto a bed of incandescent coal a distillation of the more volatile hydrocarbons begins. This distilled matter is burned if the temperature is high enough and if sufficient oxygen is present, otherwise it escapes in yellow fumes up the chimney. As the fresh coal becomes still further heated, the less volatile matters begin to be separated. This separation takes place at a temperature lower than that temperature (about 1,000° F.) which is required to burn them; hence, if they are not subjected to this high heat before the flues are reached, they too escape. It is these less volatile substances which make the thick, black smoke and fall as soot. After the volatile matter is driven off, there remains only the coke, or fixed carbon, of the coal, and this burns without smoke.

The cause of smoke then may be: (1) An insufficient amount of oxygen to combine with the volatile gases; (2) an imperfect mixture of the oxygen and the volatile gases, or (3) a temperature too low to ignite the mixture of oxygen and volatile gases.

Waste Due to Smoke.—It is plainly evident that if the volatile gases, which have valuable fuel properties, escape without being burned, a certain amount of fuel which might help to generate steam, warm the atmosphere, etc., is lost, and at the same time smoke is generated to become a nuisance. As a matter of fact, the particles of soot escaping from a chimney which give smoke its blackness are of very little value as fuel. It is the invisible gases which escape with these particles of soot that are of most value. But as the conditions which allow the particles of soot to escape also allow the invisible gases to escape, it is practically correct to assume that the total losses are indicated by the amount of black smoke. In other words, the appearance of smoke indicates imperfect combustion, and, consequently, wasteful combustion.

When the point above noted as the fixed carbon stage has been reached, any furnace will give out no smoke, because the particles of carbon are not volatile or do not separate from the solid

mass until combustion takes place. The reason why anthracite coal burns in the ordinary furnace with but little smoke is because the proportion of fixed carbon is very large and the proportion of volatile matter very small. Generally the volatile matter escapes from the chimney unburned, but there is but little of it, and consequently little smoke and little waste. With bituminous coals the volatile matter forms a much larger proportion of the total, approximating in some coals to nearly one-half. There is consequently more smoke and more waste. The following figures, taken from Kent's "Mechanical Engineers' Pocketbook," show very forcibly the greater loss due to the more volatile coals, or coals with a smaller proportion of fixed carbon.

	Per cent.					
Ratio fixed carbon	97	80	68	60	54	50
Boiler efficiency	80	76	69	66	60	55
Loss by radiation, imperfect combustion, etc	20	24	31	34	40	45

The loss due to imperfect combustion still exists even if the free carbon and volatile gases are condensed or precipitated after they leave the combustion chamber. So-called "smoke consumers," which profess to do away with the smoke after it has reached the flue, may indeed stop the black smoke to some extent, but there is a loss of fuel efficiency just as much as if the smoke had gone up the chimney. Further evidence might be presented as to the economy of perfect combustion, but this will suffice to show that in attaining smokelessness a saving is being made.

Hygienic Questions.—It is well known that carbon, either in the porous form as charcoal, or in finely-divided particles as soot, has a very great capacity for the absorption of gases, spores and organic impurities. Breathed into the lungs it may perhaps spread contagious diseases. Even if it does not carry disease in this way, health cannot but be affected by the lung tissues becoming filled with carbonaceous matter. Dr. W. A. Daley, of Pittsburg, Pa., has stated that the death rate in that city during the eight years of partial freedom from smoke—while natural gas was in extensive use—was 1.62 per 1,000 lower than during the preceding eight years, and that since the partial abandonment of natural gas, and consequent increase of smoke, the death rate has again risen from 19.58 per 1,000 to 22.15 per 1,000.

The hygienic objection to smoke is not, however, the only one. Personal cleanliness, defacement and destruction of merchandise, household goods, books, pictures, etc., loss of sunlight, and a dozen other things demand that it be abated. The best methods of doing this are discussed elsewhere, and we will here take up a few of the various perfect combustion or smokeless furnaces whose work has proved especially satisfactory in some of the larger Western cities. It is not to be understood that the devices here described constitute all the smokeless furnaces, or indeed the best, but that they represent the types of smokeless furnaces in most common use.

Reynolds Furnace, Omaha, Neb.—An ordinance relative to smoking chimneys was passed in the city of Omaha, Neb., early in 1893, its principal clause reading as follows:

> The proprietor, owner, lessee or occupant of any building who shall, after the expiration of 90 days from the passage of this ordinance, permit or allow dense smoke to issue or be emitted from smokestacks or chimneys of any building as aforesaid, shall be deemed guilty of creating and maintaining a nuisance, and shall upon conviction of such offense, be fined in a sum not less than $5 nor more than $50 for the first offense, and upon conviction of the second offense, shall be fined in a sum not less than $50 nor more than $100, and for each subsequent violation shall be fined in the sum of $100.

In obedience to this ordinance, the leading buildings in the center of the city have provided themselves with smokeless furnaces, and among these the Reynolds furnace is considered to have given the most satisfactory service. The general construction of this furnace is shown by Fig. 1. It is the invention of Mr. Frank Reynolds, Chief Engineer of the Omaha Water-Works.

As will be seen from the cuts, the Reynolds furnace is a firebrick arch device, combined with hollow walls for preheating the air. The firebox is built entirely independent and away from the boiler, the grates being any good pattern of horizontal grates. Immediately after leaving the grates the gaseous products of combustion in passing over the bridge wall traverse a contracted opening, and are immediately deflected downward by a hanging wall. They then emerge into a combustion chamber of liberal dimensions, the exit from which is through another contracted throat area, or a checkerwork of firebrick. The gases then take the usual course through the boiler tubes to the chimney. Air is admitted into the side walls at proper points, passing through channels of considerable height but limited width, and separated from the furnace proper only by the linings and arches, which are always at a high temperature. This construction not only absorbs to a very large extent the heat lost by radiation, but returns it to the furnace, one channel discharging immediately over the fire at the front end of the grate and the other immediately behind the bridge wall at the entrance to the combustion chamber.

In August, 1894, a number of Reynolds furnaces were tested at Omaha, Neb., by Mr. Wm. H. Bryan, M. Am. Soc. M. E., and in respect to smokelessness gave results, quoted in Mr. Bryan's own words, as follows:

> Two smoke charts were taken, each of an hour's duration, and under different conditions of service, and the results were worked up by means of the planimeter. On the occasion of the first test at Poppleton Ave., Aug. 24, the remarkably low average of 0.3% of smoke for the eight hours' run was secured. This is a most excellent showing, considering the fact that the boiler was being worked beyond its rated capacity, and that the slack coal was being used; in fact, there was no smoke at all except when the fires became dirty. On the second run at Poppleton Ave., Aug. 27, an effort was made to push the boiler to secure greater capacity. This effort did not succeed, however, but the effort made increased the smoke to an average of 2.67%, a quite satisfactory result, nevertheless. On the occasion of the last test, there was a faint blue haze issuing from the chimney all day. While it was clearly noticeable near by, it could not have been seen at all at any considerable distance, and, moreover, was not of an offensive character in any way. This faint blue haze is to some extent characteristic of the Reynolds furnace, and, in my opinion, represents the most unfavorable result that will be secured from it when properly handled. In the case of the last test it was no doubt due to the excessive amount of moisture in the fuel, over 4%, and the crowding of the fires. The first test, at Florence, showed an average of 2.79%, a most excellent result, considering the fact that eight boilers were connected with the same chimney, and that they were being fired irregularly, a number of different doors frequently being open and green coal charged at the same time. It will readily be seen that if each independent furnace should make a slight cloud of smoke when fired, the result would be quite a perceptible cloud when the firing of different boilers occurred together. In no case, however, was the smoke bad, and the occasional puffs were never black, and continued but a few seconds, although the boiler under test was being crowded much beyond its normal capacity. These adverse conditions existed to a much greater degree than on the occasion of the previous test. Observations of this and other chimneys connected with the Reynolds furnaces, indicate that under normal conditions the furnace is practically smokeless. No smoke was ever made when fires were being cleaned, and in this respect the Reynolds furnace differs radically from most other improved devices; in fact, the only time that smoke was visible at all was when the fires were carelessly handled, or were allowed to get dirty, and were forced considerably beyond their usual capacity.

In other respects very satisfactory results were also shown. The fuel used was slack coal from the Cherokee (Kan.) mines, which is of about the same quality as Illinois coal. The boilers showed an average efficiency of 56.64%. Mr. Bryan considered the furnace to be very safe and remarkably durable. No extraordinary degree of skill is required to handle it. Mr. Andrew Rosewater, M. Am. Soc. C. E., City Engineer of Omaha, Neb., writes that the only objection to the furnace is the expense of applying it to old boilers with limited head room. He also states that the furnace is used at all the water-works plants of that city, and that they are practically devoid of smoke, although a cheap bituminous slack coal is used.

Hawley Down-Draft Furnace.—A prominent member of the Smoke Commission of St. Louis makes the statement that no mechanical device has done so much toward the practical solution of the smoke problem in St. Louis, Mo., as the down-draft furnace.

The down-draft furnace which has come into most general use in that city is the Hawley furnace, the construction of which is shown in Fig. 2. As will be seen, there is a water grate, the bar of which terminate at each end in transverse drums or headers. Below this water grate are ordinary grate bars. The fuel is placed on the water grate, and all air enters the furnace at the door, passing down through the fuel to get out of the chimney. The volatile gases rising from the fresh coal are thus carried down through the incandescent mass beneath to the chamber above the lower grate, where the temperature is very high, owing to the incandescent fuel which drops from the water grate. The result is almost complete combustion, and consequently smokelessness.

Tests made in 1893 by the Smoke Commission of St. Louis showed that the Hawley furnace had an efficiency of over 21% more than an ordinary furnace handled in all respects the same. In this test a reduction of 96% in smoke was shown. In tests made by Mr. Wm. H. Bryan, M. Am. Soc. M. E., with a Hawley furnace running a Heine boiler at 25% above its rated capacity, only 0.66% of smoke was shown. To secure the best results in smokelessness, ample height of chimney is necessary. Mr. Bryan states the conditions under which it would seem inadvisable to use the Hawley down-draft furnace for smoke abatement to be:

> (1) When feed water is quite impure and cannot be readily improved, owing to the danger of burning out the fire grate tubes at the drum connections.
> (2) Where draft is poor and the boilers are hard worked.
> (3) Where the plant is of such a size and character as not to warrant the investment.

It should be stated, however, that in few cities is the feed water so bad that it cannot be easily improved; also that extending the chimney a little higher will generally insure the necessary draft.

In respect to the economy of the Hawley furnace, City Engineer E. H. Keating, of Toronto, Ont., reports a series of tests made at the water-works plant of that city in October, 1895, as follows:

> I beg to report that the Hawley down-draft furnaces attached to the four boilers supplying No. 4 engine have been in operation since June 19, being a period of 80 days to Sept. 8. The fuel consumed has been soft coal screenings, at a cost of $2.27 per ton. During the same period, No. 5 pumping engine has been operated by the four boilers attached to that engine, the fuel consumed being hard coal, grate size, such as has been heretofore used by the department. Both these engines were operated under exactly the same conditions, the same pressure on the force mains, and the same lift on the pumps, with a result that the cost per million gallons by the boilers to which the Hawley down-draft furnaces was attached was $2,906 per million gallons, as against $5,268 per million gallons for the boilers attached to No. 5. At the time the tender of the Hawley Down-Draft Furnace Co. was made, March 22, 1895, the contract price for hard coal was $4.19 per ton, and the tender guaranteed a saving of 35% in the cost of fuel.

Playford Stoker, Cleveland, O.—In regard to smoke abatement at Cleveland, O., Dr. J. L. Hess, Health Officer, writes as follows:

> The Playford stoker is in operation in our city, and is the most successful smoke-preventing device I have ever seen, as there is absolutely no smoke whatever from the chimneys on which it is operated. The American stoker is also a very excellent one, and smokes only when it is necessary to clean the grates for a period of from five to eight minutes. It is only necessary to clean the grates three times a day, so that there is not a great amount of smoke arising from its use.

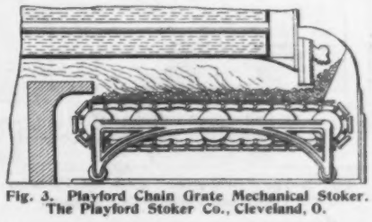

Fig. 3. Playford Chain Grate Mechanical Stoker. The Playford Stoker Co., Cleveland, O.

The ordinance relating to smoking chimneys in this city says:

> The emission into the air of any noxious gases or vapors, or offensive odors from any manufactory, building or premises within the limits of said city, injurious to health, or annoying to the inhabitants of said city, or any part thereof, shall be deemed, and is hereby declared to be a public nuisance.

The ordinance further states that any operator, owner or lessee,

who shall cause or permit any noxious gases or vapors, or offensive odors, as described in this ordinance, to issue from such manufactory, building or premises, shall be deemed and held guilty of creating a public nuisance, and upon conviction thereof in the police court of said city, shall be fined not less than $10, nor more than $100, for each and every such offense.

Fig. 3 is a sketch showing the construction and operation of the Playford stoker. It is an endless-chain, grate, mechanical stoker, operated by a small engine attached to the front and taking steam from the boiler. The construction and operation

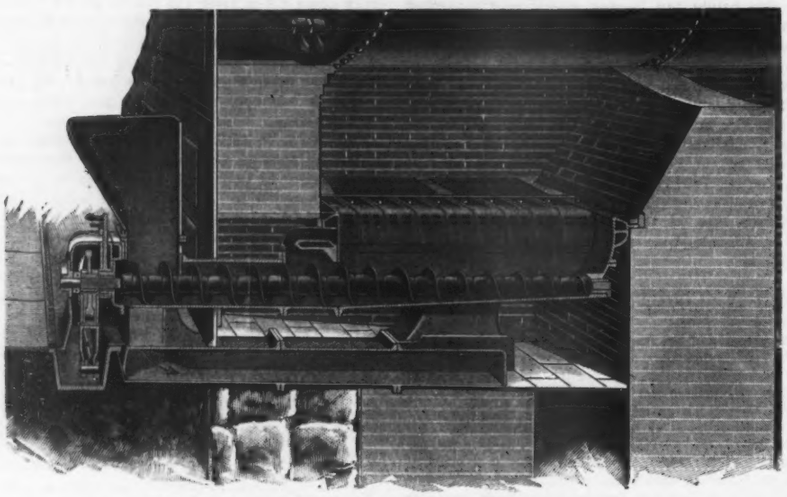

FIG. 4. THE AMERICAN UNDER-FEED MECHANICAL STOKER.
The American Stoker Co., Dayton, O.

are so clearly indicated by the drawing that no further description is necessary. The smokelessness is due to the regulation of air and fuel, so that the gases from the green coal coming into the front of the furnace pass over the bed of incandescent fuel at the rear and are thoroughly burned. One of these stokers at Sipe & Sigler's factotry at Cleveland, O., is stated to have shown a saving of 30% in fuel over ordinary grate bars.

In a more recent test made at the Cleveland water-works by Mr. C. F. Schultz, Assistant Engineer, the following results were obtained:

Fuel used	Pittsburg slack coal
Cost per ton delivered	$1.25
Boilers	8 x 16 ft., tubular
Grate area	32.37 sq. ft.
Heating surface	2,943 " "
Lbs. water evap. per lb. coal fr. and at 212°	9,128
" " " " " combust. fr. and at 212°	11,165
HP. boiler, commercial rating	187
" " as developed	229

Fig. 4 illustrates the construction and operation of the American furnace, also used at Cleveland. As will be seen, the coal is fed from the hopper by a screw conveyor, the fresh coal always moving up from the bottom and pushing the burnt coal and ashes onto the side grates. The gases from the heating coal passes up through the incandescent

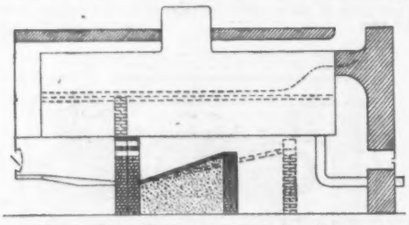

Fig. 5. The "Manhattan" Smokeless Furnace.
The Manhattan Furnace Co., Chicago.

fuel on top, and meet near the top the air from the tuyeres, as is clearly shown by the illustration. Proper mechanism controls the screw conveyor, regulates the feed and supplies the air. This stoker is made by the American Stoker Co., of Dayton, O.

Manhattan Furnace, Chicago, Ill.—Few cities have labored harder than Chicago to get rid of smoking chimneys, but owing to an inefficient enforcing of the laws, no very permanent improvement has ever resulted. A variety of smokeless furnaces have been used with very good success when properly handled, and several of these will be described. The city appears to have been a more than usually profitable field for the "smoke consumer" crank, and much harm has been done to the cause of smoke abatement through that fact.

Fig. 5 is a longitudinal section of the Manhattan furnace, designed by Mr. C. M. Higginson, of the Chicago, Burlington & Quincy R. R., and used in the large Chicago office building of that company. The cut explains itself for the most part. The broken lines show the construction when long-flaming coals are used, requiring an unusually long flamebed. Sometimes with especially long-flaming coals a firebrick arch is built a short distance to the rear of the checkerboard wall. The air admission at the firedoor, the checkerwork wall, and the long flameway are depended upon to secure perfect combustion. In tests made in 1894 the furnace gave very satisfactory results as to smokelessness, and with 21 sq. ft. of grate surface and 945 sq. ft. of heating surface, showed an evaporation of 7.36 lbs. of water from and at 212° per pound of Illinois coal. The same test showed the cost of fuel for evaporating 1,000 lbs. of water from and at 212° to be 15.2 cts. A test made at the Illinois Steel Works, in November, 1895, by the R. W. Hunt Co. showed a cost of fuel amounting to 10 cts. per 100 lbs. of steam evaporated. The furnace is manufactured by the Manhattan Furnace Co., 612 Ashland Block, Chicago, Ill.

Thomas Furnace.—This furnace is used by a number of Chicago establishments with fairly good success as to smokeless combustion. Fig. 6 shows its general construction. The air enters the furnace through hollow grate bars discharging at the rear side of the bridge wall, and from the combustion chamber traverses a contracted passage or checkerwork to get to the flues. The heat of the walls and the heated air are depended upon to consume the volatile gases. This furnace is stated to have shown a saving of 20% in fuel over ordinary grate bars in tests made at the Ellsworth Building, Chicago. It is being put on the market by the Engineering Improvement Co., The Monadnock, Chicago.

Perfect Furnace.—This furnace differs radically in its principle from any of the others yet described. As will be seen from Fig. 7, air is injected into the furnace above the grates by means of jets of steam, the arrows showing the travel of the air. This device is used at the Ajax Forge Works, of Chicago, and the city smoke inspectors report its operation to be very satisfactory. No records of the evaporative efficiency, amount of steam used, etc., can be obtained.

Barclay Furnace.—This furnace is quite extensively used in Omaha, Neb.; Kansas City, Mo., and other Western cities, and has recently been introduced in Chicago. Fig. 8 is a longitudinal section showing its construction. As will be seen, it has a firebrick arch, which rests on the side-walls and is held to the boiler by circulating pipes. The lower part of this arch is hollow, with especial-slotted brick opening into the combustion chamber. Air is admitted into this passage from the side of the furnace. The gases rising from the coal in the coking chamber pass under this arch, which brings them close to the incandescent fuel at the rear of the grate, and at the same time the hot air from the bridge mixes with them, providing the oxygen for combustion. Briefly described the method of firing the furnace is as follows:

With fire started in the furnace, the coke formed is pushed back with a rake to the bridge wall, leaving a space of about 3 ins. between the incandescent coke and the water leg. Each filling of the front chamber with green coal furnishes the coke to consume the gases from the next filling. Pushing back the coke at each loading of the fire carries with it the stone, clinkers, etc. Such accumulations are removed by unlatching the lever of the dump grate, with the furnace doors closed, spilling the dead matter into the ash pit. A push or two of the rake then covers the grate with bright coke, leaving a clean fire with no cold air passing through the boiler. This furnace is handled by the Barclay Smoke Consuming & Fuel Saving Co., Chicago, Ill.

Dorrance Furnace.—This furnace is shown in longitudinal section by Fig. 9 and Fig. 10 shows the grate in more detail. It depends for its smokelessness partly upon the very perfect combustion claimed to be obtained by the shaking grate, but more particularly upon the semi-circular firebrick arch, A. As will be seen, the furnace extends out considerably in front of the boiler, making its action something similar to that of a reverberatory furnace. The construction of the grate is perhaps the most novel feature of the furnace, and this is pretty clearly shown by Fig. 9. It will be seen that the castings, or clips, forming the grate surface have a rocking motion, the purpose of which is to break up the fire and crush the clinker by catching it between the jaws a and b. In operation these edges of adjacent clips rotate in opposite directions. For example, when a rotates upward, b rotates downward, and vice versa.

The first of these furnaces in Chicago was erected in the Rookery Building, and it proved so satisfactory that after trial the whole plant of that building was equipped with them. Since then a number of other buildings in the city have been equipped with Dorrance furnaces. In comparative

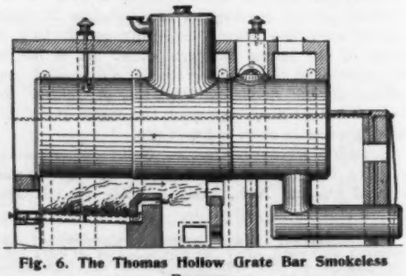

Fig. 6. The Thomas Hollow Grate Bar Smokeless Furnace.
The Engineering Improvement Co., Chicago, Ill.

tests made between this furnace and a Weber steam-jet furnace, in January, 1893, by Robert W. Hunt & Co., the following results were obtained.

	Dorrance.	Steam jet
Kind of boiler	Hor. tub.	Hor. tub.
Size of boiler	60 x 192 ins.	54 x 188 ins.
No. and size of tubes	46 4-in.	44 3½-in.
Sq. ft. grate surface	15	19
Sq. ft. heating surface	895	742
Kind coal	Screenings	Screenings.
Cost coal, per ton	$1.85	$1.85
Lbs. w. act. evap. per lb. fuel.	6,338	5,132
" " evap. from and at 212°.	6,737	5,333
Lbs. water evap. per sq. ft. heating surface (actual)	5,001	3,916
Lbs. water evap. per sq. ft. heat. surf. from and at 212°.	5,318	4,146

These two furnaces were located in different places, but the conditions of testing were the same. No correction was made for moisture in the fuel,

but the steam used in the steam-jet furnace was deducted. The Dorrance furnace made no smoke.

The nine furnaces described cover the principal types of smokeless furnaces now in general use, although there are combinations and modifications of these types too numerous to mention.

The principal types of smokeless furnaces may be summarized as follows: (1) Mechanical stokers, of which the Playford stoker, shown in Fig. 3, is

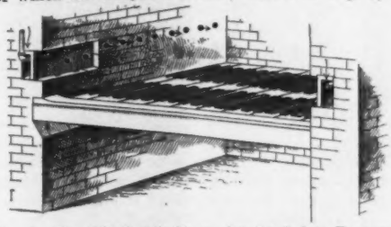

Fig. 7. The "Perfect" Steam Jet Smokeless Furnace.

one type. Several other types of mechanical stokers were illustrated in our issue of Aug. 9, 1894. (2) Furnaces with air-flues in side walls, bridge walls and grate bars, through which preheated air enters the furnace. Such flues are shown in the Reynolds, Thomas and Barclay furnaces, Figs. 1, 6 and 8. (3) Furnaces with coking arches, or a portion of the front of the grate used to coke the coal before it is pushed further into the furnace.

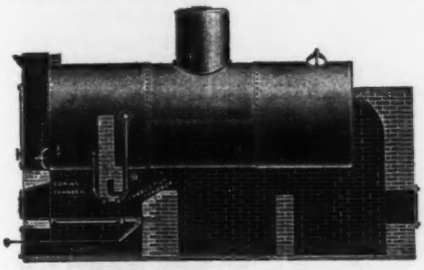

Fig. 8. The Barclay Smokeless Furnace, Barclay Smoke Consuming & Fuel Saving Co., Chicago, Ill.

The Barclay furnace, Fig. 8, uses this principle. (4) Down-draft furnaces, of which the Hawley furnace, Fig. 2, is a well-known example. (5) Furnaces with steam jets to force air into the combustion chamber. The Perfect furnace, Fig. 7, is an example. (6) Furnaces with checkerwork walls by which the volatile gases are mixed with the air and subjected to the heat of incandescent firebrick. The Manhattan furnace, Fig. 5, is an example. (7) Furnaces with a baffleplate above the

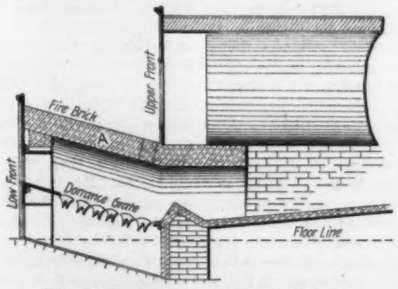

Fig. 9. The Dorrance Smokeless Furnace. The Dorrance Co., Chicago, Ill.

fire to aid in mixing the volatile gases and air, and bring them close to the fire. (8) Double furnaces, in the best form of which one grate is above the other, the top grate being used to coke the coal, after which it is dropped onto the lower grate for further combustion. The volatile gases from the top grate pass over the incandescent fuel on the lower grate. This furnace is not much used.

It will be noticed that in all of these types the aim is to mix thoroughly the air and volatile gases and to subject the mixture to a high temperature before it can reach the flues. No small part of the success of any of these devices in attaining this result will depend upon the care used in stoking.

WEATHER TABLE FOR NOVEMBER, 1895. (Furnished to Engineering News by the Department of Agriculture.)

	Stations.	Temperature. (Deg. Fahr.)				Wind.			Precipitation—rain or melted snow—inches.		
						Vel'ty in miles per hour.		Direction at time of max. velocity.			
		Average.	Max.	Min.	Range.	Average.	Max.		Total.	Heaviest in 24 hours.	No. of rainy days.
Northern Cities	Northfield, Vt.	34.8	66	0	66	8.4	38	S	5.68	1.58	15
	Portland, Me.	40.0	69	14	55	6.9	28	S	7.18	2.22	17
	New York City	46.0	72	24	48	13.4	42	W	3.58	1.38	12
	Pittsburg, Pa.	45.4	74	22	52	6.4	30	W	2.24	.68	14
	Chicago, Ill.	36.5	67	8	59	19.3	53	S	5.60	1.77	12
	Omaha, Neb.	36.8	72	2	70	9.0	36	NW	1.06	.52	5
	St. Paul, Minn.	30.6	67	5	72	7.3	25	SE	.85	.36	10
	Duluth, Minn.	29.0	58	1	59	7.5	28	NW	1.65	.73	11
	Bismarck, N. D.	22.2	64	11	75	7.7	30	NW	1.00	.62	7
	Average	35.7	68	6	62	9.5	36		3.27	1.10	11
Southern Cities	Washington, D. C.	56.0	80	31	49	8.9	38	NW	3.38	1.34	13
	Louisville, Ky.	45.7	79	22	57	7.9	37	SW	7.01	2.00	13
	St. Louis, Mo.	43.2	76	16	60	11.9	42	NW	3.98	1.63	10
	Savannah, Ga.	58.1	82	34	48	8.5	30	NW	3.74	1.42	9
	Kansas City, Mo.	41.1	75	10	65	9.7	38	NW	3.05	1.92	7
	Jacksonville, Fla.	61.0	84	35	49	7.3	25	N	3.12	1.22	13
	Chattanooga, Tenn.	51.5	77	26	51	6.7	36	W	1.71	1.24	6
	New Orleans, La.	60.5	81	37	44	9.0	36	N	.69	.48	4
	Memphis, Tenn.	51.5	74	27	47	10.1	44	SW	5.54	2.55	9
	Palestine, Tex.	54.7	79	29	50	6.4	26	N	4.33	1.13	7
	Average	52.3	79	27	52	8.6	37		3.64	1.49	9
Western Cities	Helena, Mont.	32.4	61	1	60	8.4	45	W	.77	.38	7
	Port Angeles, Wash.	43.6	60	29	31	4.5	24	W	3.04	1.29	15
	San Francisco, Cal.	56.2	83	42	41	7.7	36	W	1.78	1.06	7
	Salt Lake City, Utah	37.8	66	20	46	4.9	30	S	2.44	.77	9
	Santa Fe, N. Mex.	35.0	57	9	48	6.4	42	SW	0.18	.36	11
	Denver, Colo.	37.8	75	2	73	8.0	40	NE	0.27	.22	2
	Yuma, Ariz.	60.8	85	34	51	6.8	34	SE	0.37	.37	2
	Average	43.4	70	20	50	6.7	36		1.41	.64	8

The mechanical stoker eliminates this variable in a very large measure, and some of the other furnaces do to some extent. It rests with the stoker, however, to make the most of these furnaces as smoke consumers, so to speak. A poor stoker will cause almost any furnace to smoke, and, on the other hand, a good stoker will make very little smoke with a pretty poor furnace.

Besides the fireman another factor, which enters into the success of a furnace as a smokeless burner and still more as an economical burner of fuel, is the character of the coal used. The same furness may give very different results in smokelessness and economy of operation with different coals For example it is entirely possible for a fire brick arch, checkerwork wall or similar furnace to show long life with a very poor Western bituminous coal or lignite which would soon burn out with the high grade bituminous coal of the East. For a furnace of simple and cheap construction the fire brick arch or partition furnace is one of the very best types for smokeless combustion, because of the regenerative action of the fire brick in absorbing heat when the fire is very hot and giving it out to ignite the gases when fresh coal is put on and the fire is cooler. The difficulty with the fire brick arch furnace is that under very high temperatures the fire brick are likely to melt and contraction and expansion are also likely to make it short lived. A glance at the accompanying illustrations will show how commonly the fire brick arch or partition is depended upon to abate the smoke in furnaces of widely different design and methods of operation in other particulars.

Cost of Smokeless Furnaces.—The extra cost of any of the ordinary smokeless furnaces over the ordinary grate bars depends entirely upon the conditions. Where the furnace room is contracted and the chimney too low, the cost will be considerably greater than if these conditions are more favorable. Obviously, much will depend upon the style of furnace also. In a large plant a small daily saving aggregates a large amount in the course of a year, and extra cost which brings about this saving is justifiable, while in a small plant it would not be. There is always a saving, due to the more perfect smokeless combustion, however small the plant, and where a plant is worked to its full capacity this saving is greater than if it is worked to half its capacity. The increased expense of installation, and the saving due to more perfect combustion, must be integrated for each individual case. In a general way it may be said, however, that the saving will, in nine cases out of ten, pay the interest on the increased investment.

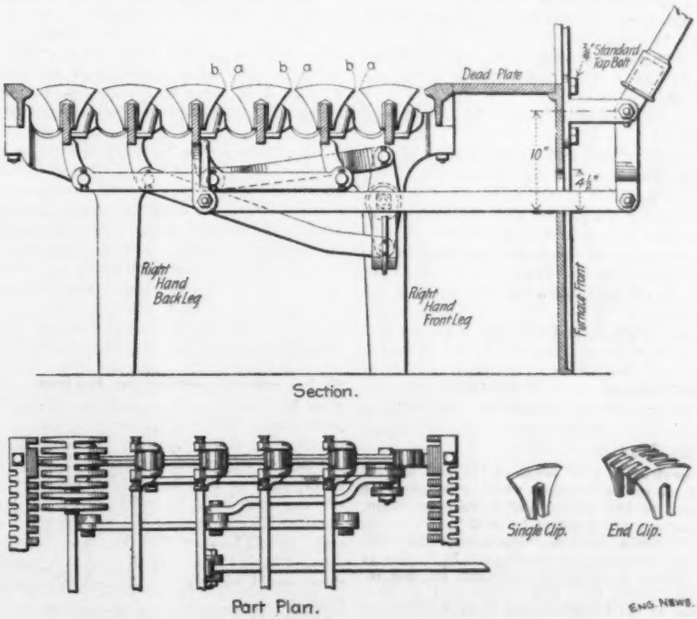

FIG. 10. SHAKING GRATE FOR DORRANCE FURNACE.

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ADVERTISING RATES: 20 cents per line agate measure. Want notices, special rates, see page 20. Rates for standing advertisements sent on request. Changes of standing advertisements must be in hand on Monday afternoon: new advertisements, Tuesday afternoon: transient advertisements by Wednesday noon.

The premiums offered by the Engineering News Publishing Co. for the best graduating theses submitted by graduates from engineering schools in the United States or Canada in 1895, have been awarded as follows:

The second prize of $50 is awarded to the thesis entitled "Gaging of the Dry Weather Flow of Sewage at Des Moines, Ia.," signed with the non de plume "Searcher."

Honorable Mention, accompanied in each case by two years' paid subscription to Engineering News, is awarded to the following theses:

1. "The Efficiency of Nozzles for Small Water Motors," by "Cone Tips."
2. "The Effect of Magnesia on the Ultimate Strength of Cement When Subjected to Freezing," by "Magnesia."
3. "The Transmission of Power by Compressed Air," by "M."

The first prize of $75, and the third prize of $25, were withheld from award by the judges, in accordance with article 4 of the rules governing this competition, under which the right is reserved of withholding any prizes in case no theses of sufficent absolute merit to deserve them shall be received; and the rule is laid down that no thesis not deemed worth of publication in full shall be entitled to a prize.

The names, addresses and colleges of the authors of the above theses are disclosed in the following letter from Mr. Chas. Warren Hunt, Secretary of the American Society of Civil Engineers, who received the theses and delivered them to us, retaining the accompanying sealed envelopes until our report to him of the awards:

Sir: As requested in your favor of the 21st inst., I have opened the sealed envelopes which accompany the theses entered for the Engineering News competition, and find that the authors are as follows:

"Searcher's" thesis entitled "Gagings of the Dry Weather Flow of Sewage at Des Moines, Ia.," has as its authors, Messrs. J. A. Moore, Callender, Ia., and W. J. Thomas, Moingona, Ia. The certicate of A. Marston Professor of Civil Engineering, Iowa Agricultural College, Ames, Ia., states that it is the original work of these gentlemen, who graduated this year in the course of civil engineering, from the above-named college.

"Cone-Tips' " thesis, entitled "Efficiency of Nozzles for Small Water Motors," has as its authors Messrs. Arthur Benj. Ilsley, Limerick, Me., and Herbert R. Thurston, Somersworth, N. H. The certificate of Robert Fletcher, Director and Professor of Civil Engineering, states that this is the original work of the above-named gentlemen, who are graduates this year from the course of civil engineering in the Thayer School of Civil Engineering, of Dartmouth College, Hanover, N. H.

"Magnesia's" thesis, entitled "The Effect of Magnesia on the Ultimate Strength of Cements when Subjected to Freezing," has as its authors Messrs. Frank Haas, of Dayton, O., and John Alexander McGrew, Columbus, O. Mr. C. M. Brown, Professor of Civil Engineering, states that these gentlemen are graduates from that university with the degree of Civil Engineer this year.

"M's." thesis, entitled "The Transmission of Power by Compressed Air," has as its author Mr. T. M. Lavelle, Uniontown, Wetzel Co., W. Va. The certificate of Wm. S. Aldrich, Professor of Mechanical Engineering in West Virginia University, Morgantown, W. Va., states that this thesis is the original work of Mr. Lavelle, who graduated this year from the course of civil engineerig at the above-named university.

Yours truly, Chas. Warren Hunt,
Sec., Am. Soc. C. E.
127 East 23rd St., New York City, Dec. 23, 1895.

The judges commend the thesis to which the second prize is awarded for its excellent summary of existing records relating to the flow of sewage, but decided that the originality and technical importance of the experiment carried out by the author, were not sufficient to entitle the thesis to the first prize.

Of the theses receiving honorable mention, the first is commended for general merit as a concise and well written record of a series of experiments, and because it shows well a wide gap between theory and practice in the design of small hydrauiic motors. The facts brought out by the experiments, however, added nothing to existing knowledge of the laws governing efflux from orifices, and merely exemplify the well-known truth that manufacturers in many lines might profit greatly by designing their machines in accordance with well-known scientific principles. The thesis describing experiments to determine the influence of magnesia upon the susceptibility of cements to frost was an excellent piece of work, save that the experiments recorded were far too few in number and too indefinite and conflicting in results to warrant the conclusions reached. This vital defect made the paper in the opinion of the judges unworthy of permanent preservation in engineering literature. The thesis on power transmission by compressed air was by far the most elaborate and extensive of any entered in the competition; and had its author successfully performed all he undertook, would have deserved the highest place. Unfortunately his work was found to contain such serious errors as to reverse the favorable judgment at first formed concerning it by some of the judges, and to make it necessary to exclude it from the prize list.

The proposal of a Brooklyn electric railway company to run its cars over the Brooklyn bridge appears to deserve no serious consideration in its present form. No exclusive rights upon the bridge ought to be granted to any corporation, and it would be manifestly unjust to give the residents of one part of Brooklyn the opportunity of riding to New York without change of cars and leave the others dependent on present facilities. Again the proposition to replace the present four-car cable-hauled trains with single electric cars is absurd to those conversant with the facts. As Chief Engineer Martin has correctly pointed out, the traffic cannot possibly be handled with any shorter trains than those now used. The present four-car trains carry approximately 600 passengers during rush hours and are run at 1½ minute intervals. This gives a traffic capacity of $40 \times 600 = 24{,}000$ per hour. An electric car may carry 70 to 80 pasengers. Calling the average 75, and setting the time interval at 45 seconds, it will be seen that the traffic capacity of the present bridge tracks, if electric cars were run over them would be only $80 \times 75 = 6{,}000$ pasengers per hour.

It may be said that by keeping the electric cars down to a slow speed, a much shorter interval than 45 seconds might be adopted. In fact the cars might be moved in a continuous procession with only 200 ft. or so headway between; but to do this some special terminal facilities would have to be provided to enable several cars to receive or discharge passengers simultaneously at the New York terminus. With this arranged, it is quite possible that electric cars could be moved safely at a speed of 12 miles per hour across the bridge, with an interval as short as 200 ft. Allowing 250 ft. as the average interval between the cars plus the length of a car, it would be possible to move 250 cars per hour across the bridge if the speed were 12 miles per hour. Assuming 75 passengers per car, as before, we have a traffic capacity of $250 \times 75 = 18{,}750$ passengers per hour. Engineers will probably generally agree that it would be unsafe to run single electric cars over the bridge at a higher speed and shorter space interval than that assumed above, and it will be seen that with even this favorable showing for the single electric car system, its traffic capacity would be little more than three-quarters as great as the present system.

Nevertheless, the desirability of landing Brooklyn trolley car passengers in New York without change of cars is so great that it ought to be ac- change of cars is so great that it ought to be ac- The most practicable plan for effecting this, and a plan which has never received the attention which it deserves, is to run the electric cars on the bridge carriageways. These carriageways have a clear width of 18 ft. 9 ins. A width of 8 ft., we believe, is sufficient for the widest electric car body. The traffic on the carriageways is of comparatively small amount, hardly a tenth or a twentieth of their capacity at most, and is quite equally distributed throughout the day. By laying tracks on one side of the carriageways electric cars could be run across the bridge without the slightest obstruction to the present vehicle traffic over it. The common argument as to the frightening of horses, which is used to oppose the placing of an electric railway on a highway, falls to the ground here; for the cable cars now run close beside the carriageways, and all city horses are accustomed to mechanically propelled cars. We have opposed the application of electric traction to the present bridge trains on the ground of safety; but if single electric cars were run across the bridge under proper restrictions as to speed and clear headway, we see no reason why the requirements of safety might not be fairly met.

The advantage of the proposed innovation to all users of the bridge are obvious. Not only would gain result to those who could go from their homes to their office for one fare and without change of cars, but the travellers on the present bridge cars would gain through the relief from the present crowded condition of the cars which would result from a diversion of part of the traffic to the new channels.

It need hardly be said that if electric car tracks are laid upon the bridge carriageways, all trolley companies should have equal privileges in their use. The bridge trustees ought to lay such tracks and to open them to all the Brooklyn street railways at a moderate rental, provided no increased fare is charged by them for the additional journey. The trustees could well afford to do this, for they would be relieved of the present necessity of operating their own line during the hours of very light traffic, when the fare receipts do not begin to pay the operating expenses. The trolley companies, on the other hand, could afford to pay a rental for the privilege of crossing the bridge, for they would thereby gain heavily in their traffic. By no means the least of the advantages accruing from the proposed arrangement would be the fact that by thus providing duplicate traffic systems one would be available for use when the other was deranged. The inconvenience and loss which thousands of people suffer every time a trifling accident on the present railway line interrupts the flow of traffic is something which ought not to be endured, if any remedy for it is feasible.

The only point of real difficulty in carrying out the scheme would be to provide for the crossing at the New York side from the west-bound to the eastbound carriageway without interfering with or endangering the foot and vehicle traffic on Park Row, and affording facilities for the Brooklyn cars to discharge and receive passengers. The improvement is so important and desirable a one, however, that the design of the new terminal station on the New York side ought to be altered so as to permit this.

If the bridge trustees will carry out this plan, we

venture to say that their praise from patrons of the bridge will be as great as their condemnation has been for the work they have thus far done upon the new bridge terminals.

SMOKE PREVENTION.

The combustion of soft coal without producing smoke in offensive quantities is a problem which is continually agitating the citizens and officials of Western cities where the poorer qualities of slack bituminous coal are much used. Periodically the newspapers raise their cry against the evil, the city officials furbish up long-dormant ordinances, and a crusade against the "disgraceful smoke nuisance" is begun. As a general thing these crusades result in a temporary abatement of the trouble, but seldom in a permanent cure. Just now the cities of Pittsburg, Pa.; Cincinnati, O.; Chicago, Ill.; St. Paul, Minn., and others are in the throes of one of these agitations, which is signalized by the usual acrimonious charges on the part of the citizens and newspapers, and vigorous denials of offense and protests of ruinous expense on the part of the manufacturers, all thickly sprinkled with lack of information and ignorance of the true nature of the question.

Whichever way one's sympathies may tend in these discussions, he must, particularly if he is a dweller in some of our Western cities, admit the importance and seriousness of the problem. It is certainly a problem whose consideration in these columns needs no excuse. Every city in the world save those within reach of the Pennsylvania anthracite fields, is practically compelled to use bituminous coal, often of a poor quality, not only in manufacturing, but in its business blocks, and to a very considerable extent for household purposes. In ninety-nine cases out of a hundred this coal is used under conditions which produce large volumes of smoke. This smoke is a nuisance to business and a detriment to health, and it should be prevented. The question is how to do it, if it can be done.

The smoke problem resolves itself into three questions: (1) Has the citizen a right to demand that his neighbor shall not foul the atmosphere with smoke, if he can avoid it by any reasonable effort? (2) Is it possible, from a mechanical and business point of view, to burn soft coal without producing smoke in offensive quantities? (3) If it is possible, what is the best way to work to bring the reform about?

The first question can at once be answered, Yes. No man would deny his right to object vigorously if his neighbor dumped his garbage in the street, and the principle is exactly the same if the neighbor pollutes the atmosphere with smoke. As a matter of fact, however, this phase of the problem assumes little importance. Few consumers—practically none—permit the nuisance to continue from mere wantonness, but from carelessness, or most often probably from ignorance of methods and devices for preventing it or perhaps from fear of the great expense which they supposed is involved in abating it, even if they are not thoroughly convinced of its practical impossibility. In many cases they have tried unsuccessfully one of the many worthless contraptions called "smoke consumers," and have wrongly perhaps, but naturally, assumed that all devices are equally valueless. A very little inquiry among store-owners and the proprietors of business establishments will show numerous instances of this character. Ignorance and carelessness are responsible in nine cases out of ten for smoking chimneys, and not wantonness, and this ignorance and carelessness are often as signal on the part of the city officials as on the part of the offending smoke producer.

Turning now to the question of the possibility of smokeless combustion, we find naturally enough that it is the chief point on which the citizen and the manufacturer join issues. Yet in some respects it is a very elementary question. The secret of the smokeless combustion of coal is simply complete combustion. The conditions necessary for complete combustion, as we have stated on another page, are (1) a sufficient quantity of air; (2) the thorough mixture of the air with the gases of combustion; (3) a high temperature of the mingled air and gases. In other words, the supply of air and fuel to the furnace must be properly regulated. This means a good draft, the admission of the air in such a manner that it meets the gases at a high temperature, plenty of grate area and flameway in which the air and gases can burn, and an even and regular application of the coal. If these essentials are fulfilled in the furnace, there will be little or no smoke from the chimney; and if they are not fulfilled, no straining or condensing device designed to destroy the smoke, if we may so speak, after it has begun its journey through the flues will do much good, and, besides, it will be decidedly uneconomical. Poor hand-stoking, cramped grate area and flameway, and failure to admit the air at the proper place and in proper quantities are the causes of the smoke nuisance.

If, therefore, the offensive smoking of chimneys is to be stopped, the first task is to secure the installation of furnaces which fulfill these requirements. In many cases existing furnaces can, with little trouble, be remodeled so as to give satisfactory results, but whatever the extent or character of the changes in the old plant may be, they will, of course, cost money, and on this point the struggle will come. It is true that the extra expense of reducing smoke gives no smoke-producer the moral or legal right to pollute the atmosphere and injure the property of his neighbor, but at the same time it is of prime importance to any reform that the most forcible arguments in favor of this expense be fully urged.

There are on the market and in use to-day a number of complete combustion or smokeless furnaces. Some of these secure the requirements outlined above by mechanical stoking, others by using firebrick arches or partitions, and others by forcing air into the furnaces with steam jets, or often by a combination of these systems. Some months ago we described at length a variety of mechanical stoking devices, and on another page of this issue several furnaces of the other types are described and illustrated. Each of these furnaces has given more or less satisfactory results in preventing smoke, the excellence of the result in every case depending upon the completeness with which the requirements of good combustion were satisfied. In justice to the consumers who must bear the expense of new furnaces, however, it is not only a furnace which will prevent smoke that is wanted, but a furnace which will do it with the greatest economy, and here the problem begins to assume puzzling ramifications.

Economical combustion goes further than complete combustion; it requires that the heat evolved shall be transformed into work with as little loss as possible, and at the smallest possible expense for labor and maintenance. The furnace which will approach nearest these desiderata in any particular case will depend much upon the conditions controlling that case. For large plants the mechanical stoker, properly handled, has proved its claims to be called a very economical device as compared with ordinary grate-bar furnaces. Its advantages lie in the reduction of labor, the regular feeding of the fuel and an even temperature of the fire and boiler sheets, and the use of a poorer fuel than can be used with grate bars. The mechanical stoker, however, is not always susceptible to sudden changes in the rate of firing, and requires the operation of machinery under the adverse conditions of heat and dirt, making the maintenance expensive. It is owing to these last faults that some of the best hand-stoked furnaces prove superior to mechanical stokers in many cases. Indeed, there are not lacking engineers who claim that the best makes of hand-stoked furnaces are superior in efficiency and economy to mechanical stokers under all conditions. This is a statement which it is hard to prove or disprove by any general argument, and as it is not the province of this article to discuss the comparative advantages of machine and hand stoking, we shall not attempt to prove or disprove it here. It is sufficient to say in favor of our argument for the economy of smokeless combustion, that either mechanical stokers or certain constructions of hand-stoked furnaces can be had which in large plants will economize enough in fuel alone to pay a fair return on the money invested in them. This is far from saying that all mechanical stokers or all hand-stoked furnaces are equally economical, or that either type is better than the other under all conditions.

For small plants it may often happen that some of the ordinary grate-bar furnaces, provided with a brick arch or other simple construction, may be found preferable on account of their cheapness. The small economies which warrant expensive furnaces in a large power plant do not always warrant them in a small steam-heating plant. Smokelessness is as necessary in the small plant as in the large, but great economy in fuel is not as necessary. Consequently if a cheap furnace will secure smokelessness with only moderate economy, it may be preferable to the expensive furnace, although the latter is much more economical. The intelligent engineer will always know where to draw the line. Now, as between the stationary grate-bar furnace taking its air through the fuel and the furnace having air forced in above the fuel by steam jets or blowers, we are much in favor of the former, not only for economical combustion, but for smokeless combustion, and we think that the records of tests and experience will bear us out in our choice. There is no benefit derived from blowing steam into a furnace, except to supply oxygen for combustion that is lacking through scanty air supply elsewhere, and this oxygen can be better secured in other ways.

Whether a brick arch or steam jets be used, however, the success of the furnace, both as an economical and as a smokeless coal consumer depends in a large measure upon the care and good judgment with which the stoking is done. However well designed a furnace may be, if it is stoked by shoveling in great charges of green coal at more or less infrequent intervals as the fire shows signs of needing replenishing, it will smoke. The ignorant or untrained stoker is a very important factor in the causes of the smoke nuisance, besides being a great waster of fuel. Probably from 20 per cent. to 35 per cent. of the efficiency of the fuel is wasted by the ordinary poor hand-stoking, and no one can say how much is lost in hastened deterioration of the boiler and furnace.

To sum up, smokeless combustion is merely a question of a properly-designed furnace and smokestack, and proper regulation of the supplies of fuel and air. Of course, to install a furnace which meets these requirements means an increased first cost over the installation of the brick box with a grate at the bottom which often passes as a furnace. It is a cost, however, which the public is justified in demanding to secure the single item of smokelessness, and when, as a matter of fact, the saving in fuel and boiler repairs soon pays for the improvement, there should be no hesitancy in demanding it.

We come now to our third question, as to the best manner of securing a permanent reform of the smoke nuisance. This is entirely a matter of proper legislation and administration. Nearly all of our larger cities have a smoke ordinance of some kind. As far as fixing the penalties for violation go, they are fairly satisfactory, but they all lack in not definitely providing for a proper administration. A desirable smoke ordinance must recognize that the public is still to be convinced that smoke is a nuisance which unquestionably can and should be abated.

Perhaps the first work in this direction of educating the public is to examine and test smokeless furnaces, and this work can be done only by the city, and the best way to provide for it is in the ordinance itself. Such a clause should be of something like the following provisions:

The duty of enforcing this ordinance shall be in the hands of the chief officer of the Health Department, who shall be assisted by an engineer of tests and such inspectors and assistants as may be necessary. The duty of the engineer of tests shall be to examine and investigate the construction, operation and safety, and to test the smokelessness, efficiency and economy of installation and operation of such smokeless furnaces as may be submitted to him and deemed worthy of test, and to report to the chief health officer fully the results of these tests and investigations, and such co-ordinate in-

formation regarding difficulty of management, favorable or unfavorable influences, durability, etc., etc., as may be obtained from these tests and other reliable sources. These reports shall be printed and distributed among steam users and others at the discretion of the chief health official, and shall at all times be free to the examination of the citizens of said city.

The expense of installing and testing any furnace shall be borne by the persons submitting the furnace for test, except the salary of the engineer of tests and his assistants, who shall be employees of the city, and all tests shall be conducted under conditions acceptable to the engineer of tests and in such a manner as he shall prescribe.

Coupled with the smoke ordinance there should be a clause added to the building law which should provide that no furnace should be installed in any new building, or replaced in an already existing plant, unless it met the approval of the Health Department officials in respect to smokelessness. The proper precautions to prevent smoke can be taken more easily at this time than after the building is completed and occupied, and it is little less than idiotic to have a strict smoke ordinance and at the same time no provision in the building law to insure the proper construction to prevent smoke.

The provision just outlined for furnishing to smoke producers technical advice and assistance regarding means and appliances for smoke prevention is just as important as provisions for adequate inspection and legal prosecutions. Not only does it insure the use of satisfactory devices, but it encourages the efforts of steam-users by giving them aid and assistance in selecting the most effective and economical appliances for smoke prevention from the endless number of good, bad and indifferent inventions which appear to the average purchaser to be of equal merit. It makes them feel secure that they will not expend money on useless devices to no end. The intelligent and faithful health officer can carry the educational work still further by encouraging a public sentiment against the evils of smoke, without which sentiment the best smoke law will be fruitless.

LETTERS TO THE EDITOR.

Compressed Air Locomotives; New Orleans & Western R. R.

Sir: We have to-day thoroughly tested our compressed air locomotives, special cars and track system at our extensive terminals at Port Chalmette, and now state that the same are an unqualified success.

We handled as much as 80 tons over a space of 6,000 ft., 2% grade, maximum curves of 75 ft. radius, and as a test, took a train of 80 tons throughout our yards, starting with 485 lbs. pressure and losing but 5 lbs. the entire distance.

The saving of labor is very large, and fire risks around the cotton sheds, cotton compresses and sorting yards are reduced to the minimum by the use of my new system, using compressed air locomotives.

Respectfully yours, A. H. Swanitz,
Chief Engineer and General Manager, N. O. & W. R. R.
New Orleans, La., Dec. 16, 1895.

(The terminal system was described and illustrated in our issue of Nov. 21. The locomotives were built by H. K. Porter & Co., of Pittsburg, Pa.—Ed.

Trestle Filling on the Northern Pacific R. R.

Sir: In regard to the articles on trestle filling in your issue of Nov. 28, I would say that during the past five years I have done a large amount of bridge filling and ballasting on this Division, making use of steam shovel and trains for handling and delivering the material. In the first place, permit me to state that we have used the best equipment in the possession of the company for this class of work, and our best results have been shown in cases where first class equipment was used. In other words, locomotives and steam shovels have always been of the best grade in our service.

We have made use of platform cars 41 ft. in in length with an extension apron on either end of 12 ins., giving us a total length of 43 ft. over all (5 ins. space between platforms) and 9 ft. in width. These cars contain an average of 18½ cu. yds. of gravel or sand.

When our haul is less than seven miles, we use only one train, allowing the steam shovel to remain idle during the absence of train delivering the load. This time is made use of in moving the shovel, furnishing fuel, water, etc., and doing the necessary "tinkering" which I find is always necessary in this class of work. We are, therefore, able to keep the men busy every moment while the train is being unloaded. When the haul is greater than seven miles, we have provided two trains, one being engaged with the steam shovel while the other is hauling and unloading. These trains are given working orders from 6 a. m. until 6 p. m. They avoid the time of our regular trains, but we favor them to the extent of allowing them to stop freight trains either at the gravel pit or at the destination of the material, in case it is necessary to allow them a few minutes additional time to dispose of the load.

The steam shovels which we have in use are the Thompson shovel, made at Bucyrus, O., and they have rendered very satisfactory service. We use the Barnhardt unloader. It has been necessary of course to increase its size in width and height in order to displace the heavy loads which our large cars contain. We have made many improvements in this device, rendering it more durable and efficient.

The foreman of the gang is usually a conductor, but, when our work is located between telegraph stations and telegraph service is necessary, we sometimes provide a foreman who is also a telegraph operator, thereby saving the expense of one man in either case. In cases where a conductor is selected, in addition to handling work in the pit and at the destination he serves in the capacity of conductor. In extremely long hauls we have employed two engines and crews hauling and one loading. In this case one conductor acts as foreman in the pit and has charge of the men at the dump as well as those with the shovel. We manage to keep him pretty busy with this work. He keeps the time of all men employed on the work, and certifies to the time of the men engaged handling locomotives and machinery, and also conductors, brakemen, laborers, etc., engaged in the work. His remuneration is considerably in excess of that paid to regular conductors.

Respectfully yours, Jos. McCabe,
Superintendent, Northern Pacific R. R.
Tacoma, Wash., Dec. 16, 1895.

Filling Trestles on the Canadian Pacific Ry.

Sir: I have just read with pleasure the editorial on filling trestles in your issue of Nov. 28, and while the matter is quite unimportant, I may point out that the reason for using air-dump cars is not, as stated, the avoidance of danger to the men employed, for we have never experienced any difficulty in that regard, but to avoid expense in filling side-hill trestles, of which we have a very large number in the Fraser and Thompson canyons. It will be at once apparent to you that in filling such trestles by means of ordinary unloading plows, a large amount of rehandling of material is involved, the material accumulating too rapidly on the upper side; and with one-sided plows, there is always more or less difficulty and delay, especially on curves. By means of the air-dump cars the material is put at once where it is wanted.

Side-dump cars were called for by the officers on our Pacific Division to meet the special conditions existing there. Objection was made to their use because of the difficulty and danger of working them on trestles, and this led to the use of air in working them. It was from this, I suppose, that Mr. Peterson got his idea that the danger to the men was the moving cause of their adoption.

Yours very truly, W. C. Van Horne,
President, Canadian Pacific Ry. Co.
Montreal, Dec. 16, 1895.

(In the paper by Mr. Peterson describing the work on the Canadian Pacific Ry., which was published in the same issue with the editorial referred to, it was stated that the slow and dangerous work of dumping cars by hand was one of the reasons for the adoption of cars operated by mechanical means. These latter cars certainly do the work much more quickly, safely and satisfactorily than it could have ben done in any other way.—Ed.)

The Relative Advantages of Hand and Mechanical Stoking.

Sir: With much pleasure I have read the article and editorial on "Smoke Prevention," which are to appear in an early issue of your paper. There are two points in the arguments therein set forth with which I do not concur and think they are rather mistaken ideas. You recommend ample grate area as conducing to good and, presumably, smokeless combustion I beg to advance the following argument against that statement and to quote some authorities in support of the position I take.

In Rankine, on the Steam Engine (13th Ed. Art. 306, pp. 435), the following appears: "It is best, in practice, to make the grate area at first rather too large, and then to contract it by means of fire bricks until the smallest area is obtained upon which the required quantity of coal can be burned without incomplete combustion."

In the original edition, 1854, of Mr. Charles Wye Williams' deservedly authoritative work, "The Combustion of Coal and the Prevention of Smoke," he says pp. 46: "As to the area of the grate bars • • • it is alone important that it be not too large." Mr. Williams emphasizes the last three words by the aid of italics. On pp. 41 of the same work, Mr. Williams unconditionally damns the then modern treatises on Steam Boilers for preaching as their good practice gospel a sufficiency (italics) of all areas and dimensions that occur in the designing of steam boilers. In the treatises and manuals of to-day, with one or two scholarly examples, the same condition of things exist.

In Mr. Daniel Kinnear Clark's "Steam Engine," and in the same author's "Manual of Rules, Tables and Data," there are cited numerous instances wherein shortening the grates in the boiler undergoing tests had a decidedly beneficial effect on the economy of the structure while the efficiency or capacity did not suffer.

Enough of authorities. Why is the smallest grate the most desirable from any standpoint? It raises the amount of fuel consumed per unit of grate area. What is the result? A more intense, hotter, less smoky fire. The gases of combustion are greatly increased in temperature, which means a greater difference between the temperature of those gases and the water in the boiler, and all authorities agree the greater this difference the greater the economy. I believe the advantages of a small grate and a high rate of combustion are exactly paralleled by the better known advantages and economy of high pressure steam over the old low pressure.

This completes my argument for the smallest possible grate area. It is not a theory, but I am lead to believe the Dorrance Co., of this city, are the only concern who have the courage of their convictions and whose practice is a high rate of combustion and a correspondingly small grate. Let me give one instance: In a test of the boilers in the Rookery Building, this city, each boiler in operation developed 149 HP. (34½ lbs. water). These boilers are 60 ins. × 16 ft., and each has 46 4-in. tubes. A Dorrance grate of 15 sq. ft. is under each boiler and the rate of combustion in the above test, which was made by the R. W. Hunt Co., was 46 lbs. of Indiana block screenings per sq. ft. of grate. The evaporation was 8 lbs. per pound of screenings The above practice is the result of no series of mathematical calculations and deductions, but is the result of close observation and p... tical study, what Mr. Rankine calls "empirical progress," for progress it is.

Now comes the second assertion, to which I am most decidedly opposed: You state the mechanical stoker is a most economical device for large plants. From experience, reasoning and a knowledge of these devices, I say you are mistaken.

You will admit that a good fireman will save his wages over a poor man, why? Because it takes reason to intelligently fire a furnace, the conditions of the fire are continually changing and thought, consideration and vigilance of the fireman, is the price of economy in the use of fuel and in the generation of steam. Now, if it takes reasoning power and careful observation to secure these desiderata, can a machine be substituted for a fireman? Remember the conditions in the furnace are continually changing. Does the automatic stoker accommodate itself to these variations and act accordingly?

A poor fireman is the exact parallel of a mechanical stoker. The poor fireman allows the fire to burn in holes, so does the automatic stoker, for it cannot reason and remedy; the poor fireman may never level his fire, the automatic cannot perform this necessary function; the poor fireman may feed fuel to the furnace whether needed or no, the automatic stoker also passes in fresh fuel without any regard to the demand for steam or any other condition which may change. The poor fireman is an expensive institution, but I doubt if the automatic stoker is not a more voracious profit eater, and this, without considering the expense of maintaining the automatic in condition to work. All users of mechanical stokers know how prone the "Machine Fireman" is to break down without apparent cause, and they are not the cheapest device to repair.

Why do large boiler companies guarantee the efficiency of their boilers only when hand fired; simply because they know, and do it for their own protection. How shall the automatic stoker, with its almost fixed rate of feed, accommodate the fuel supply to the demand for steam? How can the steam generating capacity of a boiler be governed, even approximately, when equipped with automatic, unreasoning, unreasonable mechanical stokers?

When some geometrical genius designs a locomotive valve-motion on a par with Mr. Corliss' effort for stationary engines, when perpetual motion is assured, when miracles are performed before sane men, when the millennium arrives, then, and only then, will a machine perform operations demanding intellect with a perfection approaching God's own

work, intelligent, thinking men.

I have purposely made my remarks on stokers very general and rather assertive, for the purpose of drawing from your experienced readers interesting letters in defense, or otherwise, of fuel-saving, smokeless, automatic, patent mechanical stokers.

Yours very truly, W. W. Whitehead,
For the Dorrance Co.

Chicago, Ill., Dec. 16, 1895.

SEWAGE PURIFICATION AT PAWTUCKET, R. I.

By George A. Carpenter, City Engineer.

The City of Pawtucket, R. I., has an area of 8.72 sq. miles, and a population of 32,577, according to the census of 1895. It is divided into two principal drainage districts, known as the Blackstone River district and the Moshassuck River district.

There are at present constructed 27.16 miles of sewers in the first and 7.0 miles of sewers in the second district, all built upon the combined system, construction of which was begun in 1894.

It is with the second or Moshassuck valley district that the filter plant is connected, the sewers of the other section discharging at present directly into the Blackstone River. The section tributary to the Mohassuck River includes an area within the city of Pawtucket of 960 acres and an approximate population of 9,500. One portion of this area, covering 110 acres, is the most thickly settled of any part of the city, having an average population of 34 persons to the acre, while large parts of other portions of this district are at present unoccupied by dwellings.

About 400 acres, covering what are known as the Newell ave. and West ave. divisions of this section, are fairly well sewered by the seven miles of sewers already constructed. These sewers cover 42% of the mileage of platted streets and 60% of the mileage of accepted streets in these two divisions. On these seven miles of sewers are 181 connections that are delivering sewage to the filter-fields at an average rate for the year of more than 58,000 gallons per day. More than one-half of this is ground-water which, notwithstanding underdrains are built under some sections of the sewers, still finds its way into them.

The filter-fields are located in the southern part of the city and border upon the Moshassuck River, a small stream discharging from 30 to 45 cu. ft. per sec. This stream is very much polluted both above and below the filter-fields by wastes from manufactories and it seemed best that the city should not be a party to this pollution.

Eight acres are owned by the city and 3.88 acres are covered by filter beds and tanks, 2.36 acres being the actual surface capable of receiving sewage. This area is divided into 13 beds, as shown by Fig. 1, four of which are termed sludge beds, are slightly lower than the other beds, and receive the sewage from the bottom foot of the tanks. A general view of the beds is shown by Fig. 2.

The sewage is brought to the settling tanks by gravity from the main sewers of the Newell ave. and West ave. divisions through lines of 8 and 12-in. pipes and is received into a gate-house where it can be turned into Tanks A, B or C, as desired. Two settling tanks, A and B, each 30 × 100 ft. and about 4 ft. deep have been built and roofed over. A portion of Tank B, 9 ft. sq., has been partitioned off and is called Tank C.

In Tank C an apparatus has been built for automatically shutting off the flow into the tanks and turning it into the storm overflow whenever a storm increases the amount of sewage delivered at the tanks above the average, or above any amount to which the apparatus may be adjusted. When the storm ceases and the flow returns to the average rate the gates to the settling tank are automatically opened and the sewage again flows into them. Sewage is received into the settling tanks for about 24 hours and is then turned upon the beds in rotation at the rate of 100,000 gallons per acre.

Tanks A and B connect with a distributing chamber from which the sewage can be turned upon any bed desired. Lines of 8-in. pipes lead from the distributing chamber to the beds and run along one side of each bed, excepting the sludge beds, sending off short lengths of 6-in. pipe about every 10 ft. On the side of the bed opposite these carriers, at a depth of about 5 ft. below the surface, are placed lines of 4-in. tile with joints wrapped with cloth. These tile convey the effluent to lines of 8-in. pipe, laid with cement joints and these connect with a pipe which leads directly to the river, where the effluent is discharged. By the arrangement above described considerable ateral filtration is secured for the sewage. Various forms of carriers for distributing the sewage upon the beds have been tried, but the above arrangement of pipes gave the most satisfactory results.

In the construction of some of the beds considerable poor material in the form of loam and clay was met and was all taken out to a depth of 3½ ft. in beds Nos. 1 and 2; to a depth of 3 ft. in bed No. 5, and to a depth of 5 ft. in beds Nos. 3, 4, 6, 7, 12 and 13. Upon the site of Beds 8, 9, 10 and 11 good sand was found near the level of the original surface and this was taken off down to the proper level for these beds and used in the construction of the other beds. In the former beds the sand still continued to a depth of 5 ft. and more below the finished surface in its natural state. Beds 12 and 13 were filled with sand hauled from another place.

Mechanical analyses of two samples of sand used, made at the Lawrence Experiment Station are as follows:

	Ten per cent finer than:	Uniformity coefficient.*
Sample 1	0.204 min. diam.	2.7
Sample 2	0.158 min. diam.	3.9

*Ratio between the diameter at the 60% and that of the 10% point.

Work was begun at these fields in 1893. Two tanks were built; one was roofed over, and some portions of the land were leveled off and prepared

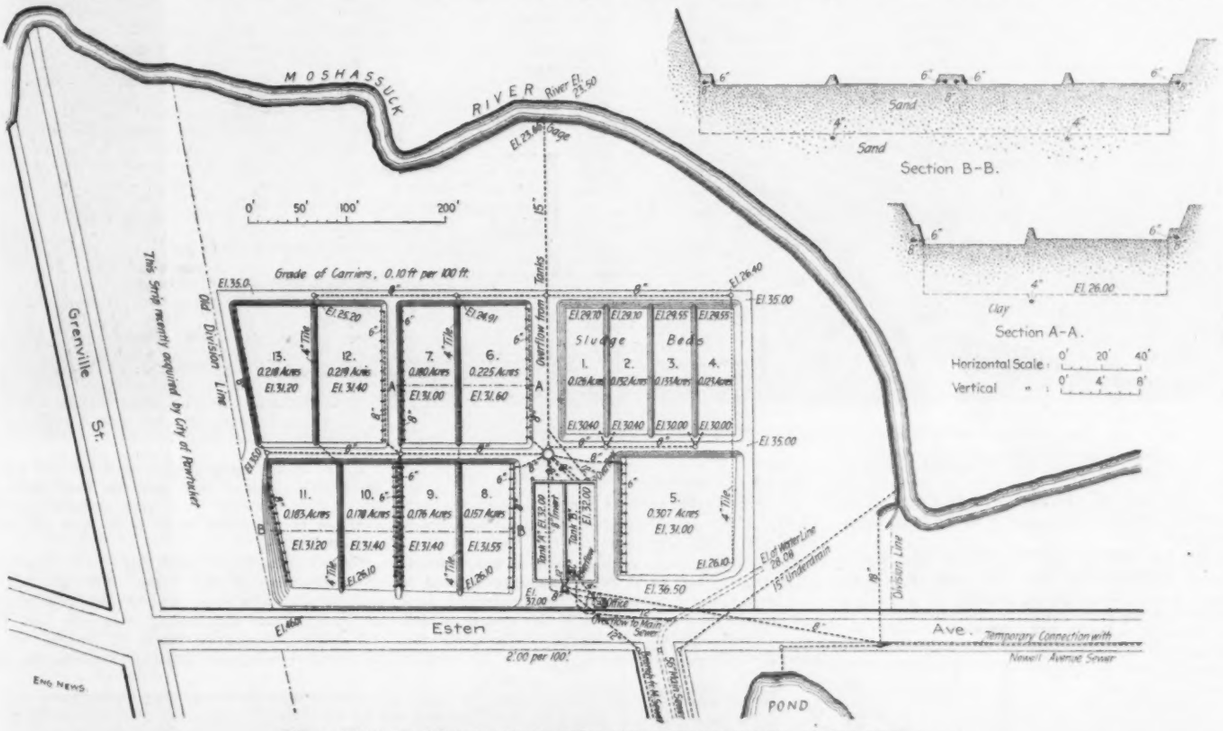

FIG. 1. PLAN OF SEWAGE FILTER BEDS AND SETTLING TANKS, PAWTUCKET, R. I.
Geo. A. Carpenter, City Engineer.

to receive sewage during the winter of 1893-4. The organization of a Board of Public Works in 1894 placed the continuance of this work, formerly under the control of a Board of Sewer Commissioners and their engineer, Arthur R. Sweet, C. E., in the hands of the city engineer. Work was renewed in September, 1894, upon the present plans and before winter, Beds 1, 2, 5, 6, 7, 8, 9, 10 and 11 were prepared and were receiving sewage. This last year, Beds 3, 4, 12 and 13 have been built, and the whole tract has been graded, sown and sodded so as to present a neat and attractive appearance. On account of the nearness of this plant to residential sections of the city more pains were taken than otherwise might have been to give it a good appearance.

Last winter the beds were all left with smooth surfaces as in summer. Frost entered the beds to various depths, reaching in some cases 14 ins. Ice also formed on the surface of the beds, at times to a thickness of 3 or 4 ins. Notwithstanding this, sewage was applied to the beds about as usual and although it remained much longer upon beds where there was considerable frost, it finally disappeared and no inconvenience was caused, for the reason

that a sufficient number of beds were prepared and an interval of four or five days could be allowed between doses.

During the year ending with November, 1895, the following quantities of sewage have been cared for at these fields:

	Total gallons per month.	Average gallons per day.
Dec.	900,000	34,961
Jan.	2,379,000	76,761
Feb.	2,178,000	77,785
March	1,971,000	63,580
April	1,683,000	56,100
May	2,559,000	82,548
June	1,671,000	55,700
July	1,561,000	50,354
August	1,520,000	49,032
September	1,225,000	40,833
October	1,651,000	53,258
November	1,882,000	62,700
Total and average....	21,189,000	58,000

perature of the sewage was 38°, the lowest being 36°, while the air ranged from 28° to 55°. Comparisons between the temperature of the sewage and air were made at the time the sewage was turned on the beds.

From January to September, 1895, sewage was applied to the other beds in doses about as follows:

Bed.	Doses, gallons per acre.	Interval between dose, days.
5	150,000	4 to 5
6	145,000	4
7	186,000	4 to 5
8	198,000	4
9	200,000	4
10	200,000	4
11	208,000	5

About the first of each month representative samples of sewage and of effluent are collected and analyzed. The accompanying table shows the results of the analysis:

Table showing chemical composition of sewage at Pawtucket, R. I., before and after filtration:
(Parts per 1,000.)

	Free ammon.	Albuminoid ammonia.	Total p. c. removed.	Chlorine.	Oxygen consumed.
Feb.	2.30	0.420		4.94	1.30
"	0.96	0.016	96	3.86	0.10
March	2.80	0.470		4.03	1.80
"	1.02	0.022	93	3.98	0.26
April	2.00	0.350		3.69	1.40
"	1.08	0.024	93	3.99	0.15
May	0.70	0.210		3.83	0.84
"	1.22	0.020	91	4.42	0.20
June	2.10	0.400		4.12	1.14
"	0.44	0.044	89	3.39	0.25
July	2.50	0.410		4.15	1.70
"	0.29	0.022	95	4.50	0.18
August	3.05	0.400		6.87	2.20
"	0.35	0.016	96	4.31	0.14
Sept	4.50	0.500		8.88	2.50
"	0.32	0.022	96	5.74	0.20
Oct	3.25	0.540		8.49	2.50
"	0.33	0.032	94	3.51	0.09
Nov.	5.00	0.930		7.20	3.80
"	0.41	0.010	99	4.45	0.08

The frost line under each month is the analysis of the representative of sewage and the second is the analysis of the corresponding sample of effluent.—(The columns of per cent. removed have been added for convenience. —Ed.)

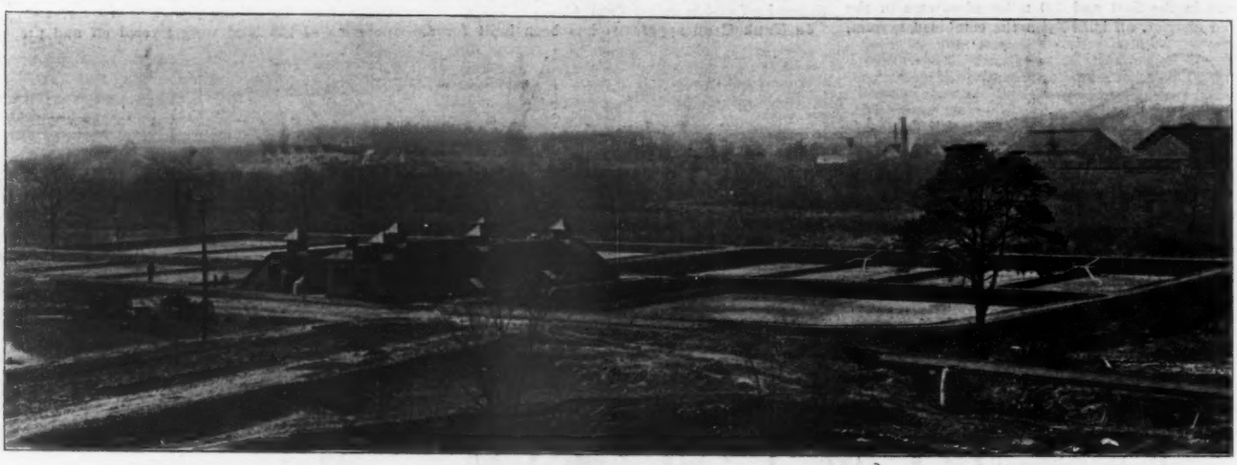

FIG. 2. GENERAL VIEW OF SEWAGE FILTER BEDS AND SETTLING TANKS, PAWTUCKET, R. I.

From Jan. 1 to March 15, 1895, frost somewhat interfered with the regular method of working the sludge beds and the sludge was held longer in the tanks and applied less frequently to the beds during this time.

Sludge has usually been applied to each bed in doses of 70,000 gallons per acre, with an interval between doses of only two or three days, but in January it was applied to Bed 1 but twice, and to Bed 2 but three times. In February Bed 1 received two doses and Bed 2 five, and from March 1 to 15, Bed 1 received two doses and Bed 2, four.

Since Sept. 1 the arrangement has been changed and the sewage is now applied to all the beds at the rate of 100,000 gallons per acre.

In January the temperature of the sewage averaged 40° F., the lowest being 34°, while the air ranged from 0° to 40°. In March the average tem-

The above table shows a removal, on an average, of 95% of the organic matter in the sewage, but it does not fairly represent the full work of these beds, for the sample of sewage analyzed is taken from the sewage as it runs to the beds after it has been allowed to settle in the tanks and does not include the heavier parts of the sewage, which are turned upon the sludge beds, while the sample of effluent analyzed is taken as the effluent runs into the river and comes from all the beds, sludge beds as well as the others.

Beds 5 to 13 are raked to the depth of about 1 in. after every fifth dose and nothing has yet collected on the surface of these beds which it has been necessary to remove.

On the sludge beds the sewage forms a thin coating which dries and curls up in the sun, resembling pieces of tarred paper. This is raked from the beds and composted. An approximate estimate of the amount thus taken from the sludge beds during the year would be 20 cu. yds.

In November, Beds 1, 2, 6, 7, 8 and 9 were furrowed, as it was desired to compare the working of such beds with level beds during winter weather. Fig. 3 shows some of these beds after furrowing.

Before furrowing Beds 1 and 2, the surface was scraped and about 10 cu. yds. of dirty sand was removed from Bed No. 1 and about 12 cu. yds. from Bed 2, which is at the rate of 8.3 cu. yds. per 1,000,000 gallons of sewage filtered in the case of Bed 1, and at the rate of 9.14 cu. yds. per 1,000,000 gallons in the case of Bed 2.

One man is employed at the filter-fields all the time and has communication with the city engineer's office by telephone, from which he receives his directions, and where quite complete records are kept of the amount of sewage received and its disposition. During the year the beds have disposed of the sewage in a very satisfactory manner and no offensive odors have been associated with the work.

The construction of these beds have been under the supervision of the writer, who has had associated with him as an advisor upon general plans of construction and results obtained, Mr. Geo. W. Fuller, Biologist, lately in charge of the Lawrence Experiment Station. Outside the price of the land about $12,000 has been expended in the construction of the plant.

FIG. 3. VIEW OF BEDS 6, 7, 12 AND 13, SHOWING BEDS 6 AND 7 AFTER HAVING BEEN FURROWED.

A bill to raise the level of Lake Erie, and perhaps that of other lakes, by a dam across the Niagara River near Buffalo, is to be introduced in the House and Senate by Representative Griswold, of Erie, Pa., and Senator Brice, of Ohio. The bill will practically call for a thorough investigation of the physics and hydraulics of the great lakes by the U. S. Engineer Corps.

THE NEW STEEL ARCH BRIDGE OVER THE NIAGARA GORGE.

By Orrin E. Dunlap.

One of the great engineering feats of the coming year will be the construction of a steel arch bridge across the Niagara gorge. This chasm is now spanned by three bridges. One is of the cantilever pattern, while two are of the suspension type. The cantilever bridge is the property of the Michigan Central R. R., while one of the suspension bridges is owned by the International Railway Suspension Bridge Co., and affords accommodations to the trains of the Grand Trunk Ry., and the other is the property of the Niagara Falls & Clifton Suspension Bridge Co. It is this latter structure that the steel arch referred to is to replace, and when completed it will have the greatest span of any steel arch ever built. From cliff to cliff the distance is 1,268 ft. The span proper of the arch will be 840 ft. In width the bridge will be 49 ft., the present structure being but 17½ ft. About 23 ft. of the center of the new bridge will be devoted to a double-track trolley line, and on each side of this will be a carriageway about 8 ft. wide, while beyond these cariageways, on each side, there will be elevated walks, each about 3ft. 9 ins. wide, for pedestrians. The center of the Canadian end of the arch will be on the exact center of the present suspension structure, but on the American side it has been found necessary to carry the center a little to the south in order that the foundation abutments may avoid the portal of the Niagara Power Co.'s tunnel. It is estimated that fully 4,000,000 lbs. of steel will be needed in constructing the bridge, and thus the condition of the steel market becomes a very important factor as to the time of letting the contract. The plans for the superstructure are not as yet completed, but it is expected that they will be in the hands of the bridge company early in the coming year, and that the contract will be awarded in January.

In order that the work of erecting the superstructure may begin early in the spring, the foundation abutments have been built this fall. These are located down in the gorge, a short distance from the water's edge, and there are two on each side of the river, about 50 ft. apart. In their construction a small coffer-dam was sunk to keep out the water of the river and the tunnel stream, and was kept dry by a contrifugal pump. The excavation was carried on inside the coffer-dam to a depth of about 12 ft., where solid rock was found. On the New York State side much of the excavation was through "muck" from the tunnel. The rock formation was cut in steps, as shown in Fig. 1, and on this the abutments were built with a concrete base, capped with granite ashlar masonry, the granite being brought from Chaumont, Jefferson Co., N. Y. Four heavy anchor rods are built into each abutment as shown in the engravings.

The site of the contemplated structure has been the scene of remarkable incidents, both in bridge construction and bridge destruction. The incidents in the history of the several bridges at this point are peculiarly significant of the progress of the locality, and the effort and desire of the Bridge Company to keep pace with the demands made upon their facilities for crossing the Niagara gorge. In the early days crossing was made at this point by means of ferry boats, but the need of a bridge was early apparent and the first step in its construction was taken when ropes were carried across the river on an ice bridge. The original suspension structure had wooden towers and floor and was completed on Dec. 29, 1868. The formal opening occurred on Jan. 2, 1869, New Year's Day having been too stormy to allow people the pleasure of crossing. The towers, as orig-mally erected consisted of 12 × 12 in. timbers. Each leg consisted of four such timbers, 16 of which were grouped together under the saddle plate for the support of the main cable. In 1887, the work of replacing the wooden structure with steel was commenced, and shafts were sunk for new and stronger anchorages to take the strain of the two additional cables required to support the additional weight of the superstructure as well as the weight of the wider floor. Then 2¼ in. steel ropes, 7 of which make up each cable, were placed in position and the suspenders for supporting the trusses were attached to the cables. The trusses, in 30 ft. sections were built out from each end until they met in the center and were there connected, after which the work of removing the old wooden structure was begun. Two gangs of men worked day and night, and the traffic was not interrupted. On the night of June 12, 1888, the last part of the old bridge was removed and connection was made with the new trusses, thus for the first time giving a double roadway from end to end. On Dec. 15, 1888, the last man was discharged from the work, the bridge being completed.

Within one month therefter, on the morning of Jan. 10, 1889, the Niagara gorge was visited by a wind storm of such destructive force as to break a fastening of one of the principal storm stays of the bridge, which left it to the mercy of the gale, with the result that the entire suspended structure was carried away and fell on the banks and in the river, leaving nothing but the towers and cables as a monument to a large outlay of money and 18 months of hard labor.

The directors were hastily summoned and within 48 hours orders were placed for the material required for rebuilding the bridge. Work was carried on night and day in the various establishments, so that delivery of material was made upon the ground in 70 days after the destruction. The work of rebuilding commenced March 22, 1889, and occupied 38 working days, so that 117 days after traffic was suspended, or on May 7, 1889, the bridge was reopened.

At that time the bridge company believed they were building of sufficient capacity for many years to come, but seven years have not yet elapsed and they find their structure inadequate to the demands. The principal reason for this is the de-

FIG. 1. THE NEW STEEL ARCH BRIDGE OVER THE NIAGARA GORGE. FOUNDATION FOR NORTH ABUTMENT ON AMERICAN SIDE, ADJACENT TO PORTAL OF NIAGARA POWER CO.'S TUNNEL.

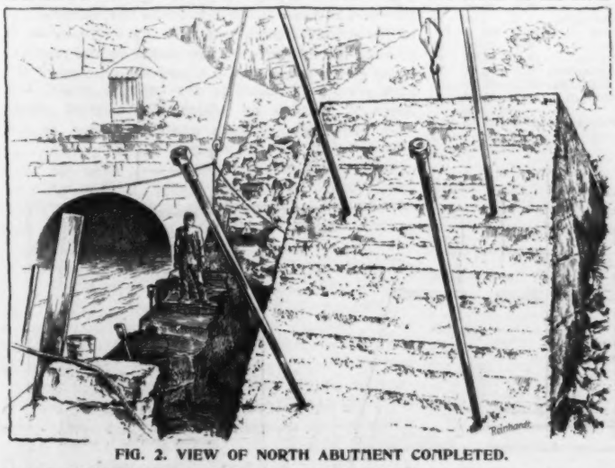

FIG. 2. VIEW OF NORTH ABUTMENT COMPLETED.

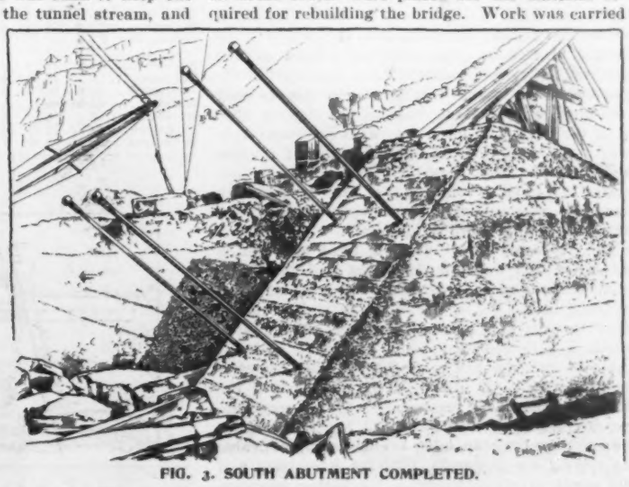

FIG. 3. SOUTH ABUTMENT COMPLETED.

velopment of electric railway lines. On each side of the gorge this development has been most marked, and there is a desire to have a bridge over which the electric cars may run. Located as is the bridge, right at the gates of both Niagara Free Parks—the New York State Reservation on one side and Queen Victoria Park on the other—and right in front of both the American and Horseshoe Falls, it is a delightful scenic spot, the view from which will never be interrupted by a bridge being built closer to the great cataract. With trolley cars in operation across it, it will naturally increase in financial value, while affording visitors to the Falls an unsurpassed view of the great cataracts.

FIG. 4. SITE OF FOUNDATIONS ON CANADIAN SIDE.

RAILWAY CONSTRUCTION IN THE UNITED STATES IN 1895.

The records of railway construction for the past year, published by two of our contemporaries, while differing materially as to the totals, combine to show that the total mileage of new railway built in 1895 is smaller even than that of 1894.

The "Railway Gazette" gives a total of 1,428.4 miles for 33 states and territories, and says that while this may be increased by later returns it shows that railway extension is no longer a very important factor in the industrial affairs of the country. Adverse conditions have checked the expansion of so many enterprises besides railway construction that there has been a feeling that with the advent of more favorable conditions railway construction would again become of interest and influence. But, says the "Gazette," we apparently shall have to conclude that railway extension hereafter will be small, as compared with what has been done in quite recent years.

The "Railway Age" gives a total of 1,782.39 miles for 163 lines in 34 states and territories (giving 25 miles to Kentucky, which state is not included in the list of the "Gazette"). This paper says that in only two years since 1865 has so small a mileage been built, and that most of the new mileage has consisted of short branches and extensions. It expresses the opinion that the bottom has now been reached, and that a moderate improvement may now be looked for, as materials are exceedingly cheap, labor is abundant, practicable enterprises are numerous, business is reviving and the needs of many localities for better transportation facilities must be met. It concludes that while the development of electric railways has had a repressive effect upon many local projects it does not affect transportation lines of any considerable importance, and that railway construction will still go on, although the rate of former years may not again be equalled.

The following table shows the records of new mileage by states as given by these two papers, from which it will be seen that there are considerable differences in detail, but the general result is the same, each showing a steady reduction since the great total of nearly 13,000 miles in 1887. The annual totals of the "Age" are generally somewhat higher than those of the "Gazette."

The total mileage of 1895, taking even the highest figure, is said to be smaller than that of any year since 1865, with the exception of two years between 1865 and 1877. The following table shows the general rate of construction since 1877, and the steady decline since 1887 is very marked. Recognizing the difficulty of obtaining complete and accurate records, (a difficulty which we had to encounter in preparing the detailed records of railway construction which we published for several years when such construction was in active progress) we have given the higher figures for the past few years as being the more likely to represent actual conditions, although these figures may include some logging or other roads which should not properly be included in the returns. In any case the figures can only be approximate, but are sufficiently accurate for general comparison.

1878	2,630 miles.	1887	12,800 miles.
1879	4,750 "	1888	7,000 "
1880	6,900 "	1889	5,100 "
1881	9,800 "	1890	5,600 "
1882	11,600 "	1891	4,200 "
1883	6,750 "	1892	4,100 "
1884	3,850 "	1893	2,600 "
1885	3,600 "	1894	1,950 "
1886	8,500 "	1895	1,780 "

The "Railway Age" states that in Canada 14 railways built 192.75 miles, while in Mexico 4 railways built 76.65 miles.

Records of Mileage of Railway Construction in 1895.

	"R. R. Gazette." Miles.	"By. Age." Miles.	No. of Lines.		"R. R. Gazette." Miles.	"By. Age." Miles.	No. of Lines.
Alabama	22.5	53.49	6	Mississippi	10.0	13.00	3
Arizona	65.3	63.30	2	Missouri	50.0	53.43	2
Arkansas	38.0	32.00	5	Montana	5.4	10 10	2
California	65.5	95.50	7	New Jersey	4.6	5.00	1
Colorado	33.9	35.90	2	New York	61.6	68.81	8
Florida	38.5	71.25	8	N. Carolina	44.3	39.30	5
Georgia	67.7	81.75	7	Ohio	72.0	87.65	10
Illinois	41.8	78.33	8	Oklahoma	49.0	47.88	1
Indiana	14.9	16.92	4	Penna.	83.5	86.57	13
Indian Ter	144.0	149 71	3	S. Carolina	1.0	6.33	1
Iowa	11.1	11.66	1	Texas	185.5	224.22	13
Kansas	18.0	17.70	2	Utah	4.0	10.00	2
Kentucky	....	25.00	4	Virginia	14.0	43.00	3
Louisiana	17.0	50.83	4	Washington	2.6	2.61	1
Maine	82.0	86.14	4	W. Virginia	68.5	85.95	7
Maryland	2.0	2.70	2	Wisconsin	35.8	35.50	5
Michigan	49.5	76.90	10				
Minnesota	23.86	33.96	7	Totals	1428.4	1782.39	163

TWO-CYLINDER COMPOUND SYSTEM OF THE PITTSBURG LOCOMOTIVE WORKS.

The compound locomotives of which the Pittsburg Locomotive Works, of Pittsburg, Pa., make a specialty, are on the two-cylinder system, and the special features of the design are the intercepting and reducing valves, and the arrangements by which the engines may be worked either simple or compound.

The general arrangement of the valves and operating lever is shown in Fig. 1, the position being for working compound. Fig. 2 is an end elevation, showing the position of the valves, steam and exhaust passages, and the receiver, the latter being a horseshoe pipe enclosed in the smokebox. It will be noted that the high-pressure cylinder is heavily clothed, the cylinder jacket being of the same diameter as that of the low pressure cylinder. Figs 3 and 4 represent the respective positions of the intercepting and reducing valves when the engine is working simple and compound, these valves being placed in the cylinder saddle on the high pressure side of the engine. In Fig. 3, the reducing valve is open and the live steam from the boilers passes through a small passage from the main steam pipe to the reducing valve, and through that valve to the receiver, through which it passes to the low pressure cylinder, the effect of the reducing valve being to prevent a greater pressure in the large cylinder than in the small cylinder when both are taking live steam. The reduction in pressure depends upon the ratio between the areas of the valve and its piston. At the same time a passage is opened by which the exhaust from the high pressure cylinder passes directly to the exhaust nozzle and the atmosphere. In Fig. 3 the intercepting valve (which is a piston valve), has been thrown back to the opposite end of its stroke, closing the reducing valve so as to prevent the entrance of live steam to the receiver, while at the same time it closes the passage of the high pressure exhaust to the exhaust nozzle, and opens a passage by which the exhaust steam from the high pressure cylinder passes to the receiver and thence to the low pressure cylinder.

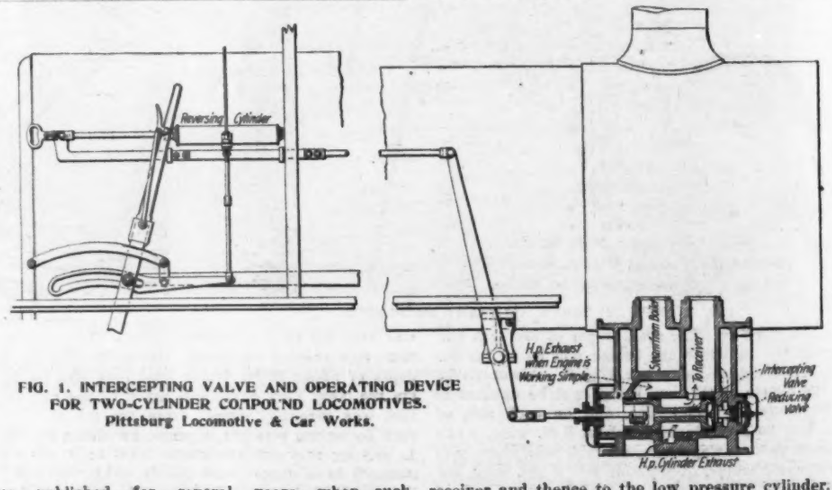

FIG. 1. INTERCEPTING VALVE AND OPERATING DEVICE FOR TWO-CYLINDER COMPOUND LOCOMOTIVES.
Pittsburg Locomotive & Car Works.

In the cab is placed an air or steam reverse cylinder, which is operated by the movement of the

reverse lever. When the lever is in any intermediate position between the ends of its stroke, as in Fig. 1, the intercepting valve is held at the forward end of its stroke, closing the reducing valve, and the engine then works compound. When the lever is thrown into full stroke, or placed at either end of the sector, the interceptng valve is pulled back, and

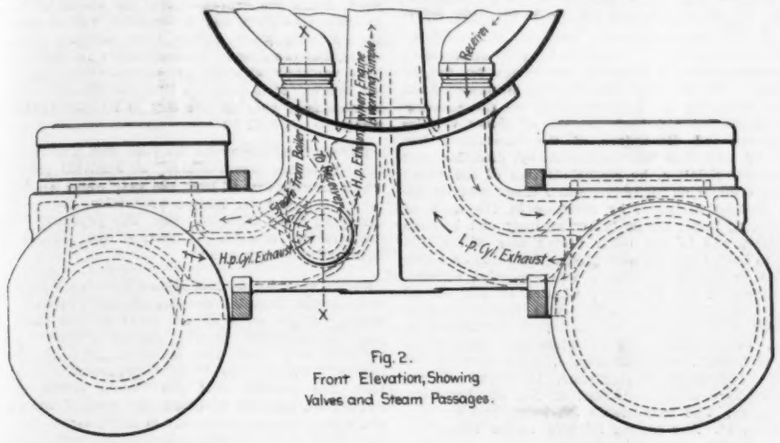

Fig. 2.
Front Elevation, Showing Valves and Steam Passages.

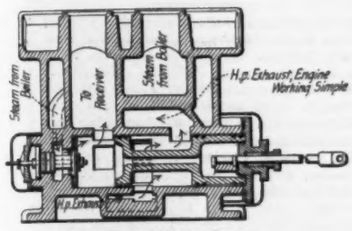

Fig. 3. Engine Working Simple.

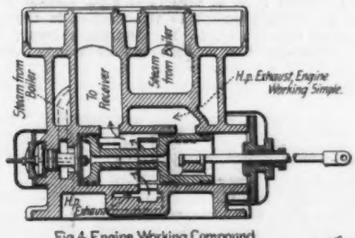

Fig. 4. Engine Working Compound.

Sections on X–X, Showing Positions of Valves.

DETAILS OF INTERCEPTING VALVE OF TWO-CYLINDER COMPOUND LOCOMOTIVE.

E. N. & M. News.

drawings and photographs from which our illustrations have been prepared.

The New York and New Jersey Bridge Commission has presented to the Sinking Fund Commission plans for three locations of New York terminals to the bridge. The first runs from 59th street and the North River east to 10th avenue, then north to 60th street, and ends at 59th street and 8th avenue, taking in the block to 61st street. The second terminal is situated between 49th and 51st streets, 9th avenue and Broadway, taking in four blocks. The third is bounded by 42nd and 44th streets, Broadway and 7th avenue. The vast amount of property included in the viaduct approach and any of these terminals caused the subject to be laid over for further study. The bridge people want the 49th street site.

A high bridge project is again under discussion for the crossing of the Detroit river, at Detroit, in the interest of the Michigan Central R. R., and it is reported that both Mr. E. L. Corthell and Gen. Geo. S. Field have been consulted with reference to the problem. The situation would demand a bridge about two miles long an 140 ft. in clear height. It is said that the Canada & Michigan Bridge & Tunnel Co. will ask the Dominion authorities, at the next session of Parliament, for power to build a high bridge. The scheme is an old one, which has always been strenuously objected to by the vessel-owners as a nuance to navigation.

The survey of the New York State canals this winter, says State Engineer C. W. Adams, will require the services of 20 to 25 surveying parties of 8 to 10 men each, in charge of an assistant engineer. The line is to be run on the tow-path, and the canal is to be cross-sectioned at every 50 ft. Careful measurements and examination of existing retaining walls must be made, and the same examination must be extended to locks, bridge abutments, waste wiers, etc. Plans based upon these surveys will be prepared for bidders upon the work of improvement.

A 6-ft. steel or cast-iron submerged pipe is to be laid at Toronto, Ont., to replace the present wooden conduit extending from the shore crib of the water-works intake to the bell-buoy. The pipe will be 2,350 ft. in length, and flexible joints will be used. Mr. C. H. Rust, Deputy City Engineer, informs us that the old wooden pipe has given much trouble, is leaky and in bad order generally, permitting a good deal of sand to find its way to the engine room. Bids for furnishing the pipe and flexible joints will be received until Feb. 16, 1896. Mr. Daniel Lamb is chairman of the Committee on Works.

The enlargement and extension of the Cincinnati water-works is to be investigated, with special reference to securing pure water and providing more efficient pumping machinery. A resolution, with many "whereases" setting forth the need for these improvements, ordering the investigation was adopted by the Board of Administration on Dec. 21. The same resolution appointed the following three engineers to conduct the investigation, with instructions to report not later than March 20, 1896: Messrs. John W. Hill and Samuel Whinery of Cincinnati, and Geo. H. Benzenberg, of Milwaukee. The engineers are especially directed to report on the advisability of other sources of supply than the Ohio river, although this is apparently not meant to shut out that source, if purification should be adopted.

The sedimentation and filtration of the water supply of the District of Columbia has been recommended by the Grand Jury at Washington. It is also recommended that the water supply be increased in quantity; that as opportunity affords all private pumps and wells used for drinking purposes should be closed, and that all buildings or streets containing sewers and water mains should be connected with the same or their occupancy prohibited. The jury says that during the past twelve years there has been a steady increase in typhoid fever cases within the district, and that the number of such cases is abnormally high. It attributes this, in part, to the water supply, which is drawn from the Potomac River.

A new sewerage scheme for North London has been recommended by a committee of the London County Council. It includes a new outfall sewer, a new intercepting sewer, and some minor work at an estimated cost of about $4,500,000. The council voted against building new sewers on the ground that they are not now necessary, and voted to adopt measures to prevent local flooding. The committee's report reviewed the history of the main sewerage system of

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Two-Cylinder Compound Locomotives.—Pittsburg Locomotive Works.

	T. H. & P. R. R. Ten-wheel.	C. H. V. & T. R. Y. Mogul.	Ala. Gt. So. Ry. Eight-wheel.
Driving wheels, diam.	4 ft. 8 ins.	4 ft. 6 ins.	6 ft. 0 ins.
Truck wheels, "	2 " 4 "	2 " 6 "	2 " 9 "
Tender wheels, "	2 " 9 "	2 " 7 "	.....
Journals, driving axles	8 x 9 "	8 x 9 "	8 " 10 "
Journals, truck "	5 x 10 "	5 x 9 "	5½ " 10 "
Wheelbase, driving	11 ft. 0 "	13 ft. 2 "	8 " 0 "
" engine	21 " 8 "	20 " 1 "	22 " 6 "
" engine and tender	49 " 9½ "	48 " 4 "	47 " 0½ "
Weight on driving wheels	101,000 lbs.	100,500 lbs.	72,000 lbs.
" total, engine	127,000 lbs.	116,200 "	112,500 lbs.
" tender (*loaded, **empty)	*78,700 lbs.	** 28,800 "	** 30,600 lbs.
Cylinders, h. p.	19 x 26 ins.	19 x 26 ins.	19 x 26 ins.
" l. p.	29 x 26 "	29 x 26 "	29 x 26 ins.
Steam ports, h. p	.....	1¼ x 18 "	1⅝ x 16 ins.
" " l. p	.....	1⅞ x 20 "	1⅞ x 18 ins.
Exhaust ports, h. p.	.....	2½ x 18 "	2⅛ x 16 ins.
" " l. p.	.....	3 x 20 "	3⅜ x 18 ins.
Boiler, diam	5 ft. 0 ins.	5 ft. 0 "	4 ft. 10 ins.
" pressure	180 lbs.	180 lbs.	180 lbs.
Firebox, length	9 ft. 0 ins.	9 ft. 0 ins.	8 ft. 0 ins.
" width	2 " 8⅝ "	2 " 6⅝ ins.	3 ft. 4⅞ ins.
Grate area	24 sq. ft.	24.2 sq. ft.	26·8 sq. ft.
Tubes, number	256	232	240
" diameter (outs).	2 ins.	2 ins.	2
" length over sheets	12 ft. 5 ins.	10 ft. 10½ ins.	10 ft. 10 ins.
Heating surface, tubes	1633 sq. ft.	1311 sq. ft.	1350·68 sq. ft.
" " firebox	152 " "	161 " "	123·17 sq. ft.
" " total	1805 " "	1,472 " "	1474·05 sq. ft.
Capacity of tank	.....	3,600 gallons.	3,500 gallons.
" " coal space	300 cu. ft.	.....	.....

London and founded its recommendations upon the history of the system and the opinions of Sir Benjamin Baker and Mr. A. R. Binnie, Engineer to the County Council. The failure of the Council to adopt the report of its committee may be due to the conservative character of the present body, as pointed out in an issue of Dec. 19. The report states that since March, 1889, there have been built 23 miles of brick and 94 miles of pipe sewers, and that during the same period 30,000 new houses have been built.

Cleveland, O., says Mayor McKisson, wants $70,000 for a garbage destroyer, $350,000 for river improvements, $1,000,000 for improved water facilities and $500,000 for sewers. Whether the city will obtain authority to spend this money depends upon the action of the Ohio legislature.

A Palisades national reservation, extending the whole length of the Palisades of the Hudson, is the subject of a bill prepared for presentation to Congress by the Palisade Commissioners of New York and New Jersey. The bill would establish a military and national park, with provisions closely following those of the parks at Gettysburg and Chattanooga. The area would include the length of the Palisades and a width extending from the middle of the Hudson to a road located parallel with the cliff and from a few hundred yards to one-quarter mile back of the face of the cliffs. The bill asks for $500,000, with which the land is to be bought and improvement commenced.

The New Jersey State Road Improvement Association will hold its annual meeting in January, and will then discuss the report of Mr. H. I. Budd, State Road Commissioner, and also the road bill to be presented to the legislature. The commissioner's report shows that during the year 46 miles of road have been built, towards the cost of which the state paid $100,000. Besides the 45 miles of roads they have been approved for 1896, there are filed applications for 130 miles of stone road, of which the average cost is about $7,-000 a mile. he first practical work for improved stone roadways began in Essex County more than 20 years ago, when, under a special law, the county built 200 miles of telford nd macadam roads. Union County next procured the passage of a general law, borrowed $455,000, nnd covered the county with a complete system of telford and macadam roads. New Jersey passed the original State-aid law in 1891. The salient features of which are that the abutting property owners along the improved roadway pay 10% of the cost, the state 33⅓%, and the county pays the remainder of the rost and maintains the road. The commissioner urges th e use of convict labor for some road making and the adoption of township committees of ordinances to allow rebates for the use of broad tires on whe rebates for the use of broad tires on wheels. He suggests that the rebate of $1 on each wheel, instead of 50 cts., as at present, and to make it compulsory that vehicles of 1,500 lbs. or more have broad tires.

FIG. 8. TEN-WHEEL TWO-CYLINDER COMPOUND FREIGHT LOCOMOTIVE FOR THE VANDALIA LINE.
Builders, Pittsburg Locomotive & Car Works.

The Chairman of the Highway Commission of Connecticut has made a statement to the effect that enquiry in 62 towns in the state shows that there are 5,000 lles of roads in these towns. Of these are 5,000 miles of roads in these towns. Of these alone 800 of gravel and 2,487 of dirt. From this it is estimated that Connecticut has from 12,000 to 15,000 miles of roads. The average cost of stone roads is about $6,000 per mile. In the 140 days in which the Highway Commission has been in existence, stone roads have been completed in 22 towns, and roads have been nearly finished in 14 more towns. A better result than this might have been reported were it not for the town elections and changes in the boards of selectmen, which delayed the making of contracts. A road built under the specifications and inspection of the State Highway Commission can be kept in repair at an expense which will not exceed $10 year per mile. The plan of commission for this year is to have al the contracts let before April 1, so that the entire season can be utilized for building the roads, and then there can be no excuse for not completing the work on them before Nov. 1, 1896.

The American Motor League is the name of a new society recently organized in Chicago for the advancement of the motor vehicle. The purposes of the league, according to its constitution, are the advancement of the interests and the use of motor vehicles by reports and discussions of the mechanical features, by education and agitation, by directing and correcting legislation, by mutual defense of the rights of such vehicles on highways, when threatened by adverse judicial decisions, by assisting in the work of constructing better roads, better sanitary and humane conditions, and in any other proper way which will assist to hasten the use and add to the value of motor vehicles as means of transit. The executive committee consists of the President, Charles E. Duryea, of Peoria, Ill.; Vice-Presidents, Henry G. Morris, of Philadelphia; H. D. Emerson, of Cincinnati, and Hiram P. Maxim, of Hartford, Conn.; Treasurer, Charles B. King, of Detroit, and Secretary, J. Allan Hornsby, of Chicago. Permanent headquarters, in charge of Mr. Hornsby, have been established at No. 335 Dearborn st., Chicago. The membership fee is $2, and the annual dues, $1. Any person friendly to the motor vehicle is eligible to membership.

Fly wheels built of structural steel instead of cast iron are being supplied to the engines in the power house of the Albany, N. Y., electrical railway, to replace the cast iron wheels, one of which burst recently. The structural steel wheels are said to cost about twice as much as cast iron wheels. Their safety, however, is so much greater that they are likely to come largely into use.

The natural gas supply of Pittsburg is soon to be increased by a new pipe line 101 miles long, which is being constructed by the Philadelphia Co. to the gas fields of West Virginia. The Pittsburg end of the line is 36-in. diameter and 14 miles long. Over 42 miles of the line is now in use, carrying gas from the Green county, Pa., wells. The entire work is expected to be completed in January, and the cost is said to be nearly $2,000,000.

A penalty of $5 per cu. yd. is the maximum imposed by the U. S. Government for the illegal dumping of mud in improved harbors; and this penalty has been enforced with good effect by Col. G. L. Gillespie, the officer in charge of the harbor of New York. A previous fine of 20 cts. per yd. had no effect upon the captains of the dredging tows, who declared it was absolutely impossible to clear out all the pockets of the scows at the designated dumping ground. The deduction of $2,000 for 400 cu. yd. dropped in the harbor in Seeptember seems to have promptly removed the impossible features referred to.

The wrought iron forging for the stern frame of the new steamship now being built at Newport News for the Cromwell Steamship Co., was shipped from the forge of the Paterson Iron Co., at Paterson, N. J., on Dec. 16. It weighed 26,000 lbs. and is said to be the largest stern frame forging ever made in this country. It occupied so much room on the car on the Erie Railway, on which it was transported 18 miles to Hudson river at Jersey City, that it was necessary to stop all westbound traffic on the road, and clear the track for two hours early in the morning so that the forging should have a right of way of both tracks, and be in no danger of touching cars on the westbound track. The outside measurements of the frame were 21 ft. 2 ins. × 28 ft. 10 ins.

The shipment of Lake Superior iron ore for 1895, according to press despatches, will reach about 10,250,000 tons. In 1892, the former record year, the shipments were 9,072,000 tons. Great preparations are being made to meet the increased demand which is expected next year. Fears are expressed that the stocks of ore now at lower lake ports may be depleted, and an actual ore famine take place before next season's navigation opens, but the fear of a short supply in 1896 seems to have vanished with the increased development of the ore ranges. It is expected that the Mesaba range will be able next year to add 50% to its this year's shipments.

The pig iron output for the year 1895 is estimated by the "American Manufacturer" at 9,387,639 gross tons, which exceeds that of 1890, the year which has hitherto held the record for largest production, the output in that year being 9,202,703 tons. The production during the last two months has been at the rate of about 11,000,000 tons per annum.

Duluth bids fair to rival Minneapolis as a flour-milling center. The Duluth "Evening Herald" estimates the output of the mills at the head of the lakes this year at 3,500,000 barrels against 2,946,292 barrels in 1894 and 2,108,119 in 1893. The milling industry began to be important only in 1889, the product that year being 85,000 barrels. The Duluth Imperial Mill holds the world's record for a single mill, having a capacity of 8,000 barrels per day. Its owners expect to build a second mill with a capacity of 10,000 to 12,000 barrels per day as soon as the market will warrant.

A social technical club, organized somewhat on the same lines as the Engineers' Club of New York, is proposed for Chicago. It is to be social in its character and to be made up of engineers, architects, railway officials and representatives of allied interests. There would be the usual accommodations of a club, including restaurant and a number of sleeping rooms, and accommodations for non-resident members would be a special feature. Charter members would pay $50 for initiation and one year's dues; the future charges to be $50 for initiations, $30 for resident and $20 for non-resident annual dues. Mr. Charles E. Billin, 1534 Marquette Building, Chicago, formerly in charge of the Bridge Department of the Pennsylvania State Co. and now with Frazer & Chalmers, is the chairman of the local committee in charge of the project. As soon as 150 favorable answers are received, the organization will be formed.

The Public Printer of the United States, Mr. Thos. E. Benedict, according to his late report, used up 4,547 tons of paper and finished 1,787,473 bound volumes and 1,182,955 pamphlets, in the fiscal year ending June 30, 1895. He has 2,736 employees in his department.

A fleet of eight new steamers for ore traffic on the lakes is said to have been ordered built by Mr. John D. Rockefeller. These steamers will be built of steel and will each have a tonnage of 4,000 tons and a draft of 14½ ft. This means vessels about 400 ft. long, by 48 ft. beam and 28 ft. depth.

A trolley dining-car is the latest innovation proposed by an enterprising Brooklyn caterer, who thus proposes to furnish a good breakfast to men going early to business. He would also serve a lunch to shoppers in the daytime and dinners to theater-parties in the evening.

An electric brake of the General Electric Co.'s make is to be tried on one of the cars of the Union Electric Ry., of Providence, R. I. There is a brake disk keyed to each axle, and when the controller handle is in the braking position the motors are converted into dynamos generating the brake current, the current from the trolley wire being automatically cut off.

Speed indicators and recorders have been placed on the engines of the new fast express trains on the Union Pacific R. R.

An electric cable traction system is said to have been devised by the General Electric Co., of Schenectady, N. Y., with a view to its application on the Erie Canal.

A grade crossing ordinance, passed recently at Chicago, provides that every train or locomotive approaching Clark and 16th streets must come to a full stop within 100 ft. of the crossing and wait until the flagman at the crossing signals that the street is clear. It is said that this is one of the means to be taken to compel the Chicago & Western Indiana R. R. to elevate its tracks. The Chicago & Northwestern Ry. is reported as intending to proceed at once to continue the elevation of its tracks, having completed the elevation on the Galena Division.